STUDY OF THE MARINE ENVIRONMENT OF THE NORTHERN GULF OF CALIFORNIA

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16. Abstract

Progress in studies of the marine environment of the northern Gulf of California is described. A ship was chartered in Mexico, staffed with local seamen, equipped for oceanographic work, and is now conducting monthly cruises of 47 stations, collecting ground observations for correlation with ERTS-1 imagery in the Arizona Regional Ecological Test Site laboratory in Tucson. Progress is reported on fabrication of instrument buoys equipped with marine-adapted DCP's to transmit ground observations via satellite to Tucson. Data handling processes are described. Coordination of work with Mexican scientists is detailed.

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Preface

Objective: To develop baseline information for evaluation of the feasibility of ERTS-1 monitoring of seasonal changes in the Northern Gulf of California environment.

Scope of Work: Regular ship cruises to acquire ground observations from 47 stations in the test site. Construction and deployment of two remote data oceanographic buoys transmitting ground observations by satellite relay. ERTS imagery analyses with reference to ground data collected. Coordination of international scientific cooperation with Mexican scientists participating in ship work.

Conclusions: Although in process of formation, definite conclusions at this time would be premature; study is in too early a stage.

Summary of Recommendations:

1. Provide additional funds to compensate for lack of NASA arrangements to keep DCP's repaired.

2. Extend contract to November, 1973 to make up for late, no-fault start and allow attainment of objective of year's coverage for quantification of seasonality.

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Type II Progress Report for Period 21 June - 31 December, 1972

Project UN 603, STUDY OF THE MARINE ENVIRONMENT OF THE NORTHERN GULF OF CALIFORNIA

Introduction

This report summarizes the work performed during the period 21 June - 31 December, 1972 on contract NASR-102: "Study of the Marine Environment of the Northern Gulf of California." The purpose of the report is to review progress of the investigation and to analyze it in the light of the objectives of the contracted research.

The primary, general objective of the program is to develop baseline information to be used in evaluating the feasibility of ERTS monitoring of seasonal changes in the northern Gulf of California environment. In order to achieve the broad objective, a number of discrete sub-objectives have been identified which are suitable for systems management as operational parts of the complex whole. These sub-objectives appear as subject headings in the main body of the text which follows.

1. Achieve Operationality for Acquiring Ground Observations.

a. Charter suitable vessel; ensure competent crew; re-fit vessel as necessary; arrange for efficient function in Mexican waters.

An informal agreement has been negotiated with the Universidad de Sonora for use of their research vessel "Adventyr." This is a 46 foot, steel-hulled, diesel-powered vessel of 17.8 gross tons, especially constructed for beaching in the extreme tidal region of the northern Gulf of California. By agreement, the charter monies paid the Universidad de Sonora have been made available to pay for ship modifications and upkeep.

Funds budgeted for charter were insufficient to cover both the required ship work and the crew salaries (captain, seaman/cook, watchman, and periodic temporary labor). Additional funds were obtained through National Science Foundation Grant P2B3497 ("Research Ship Support").

Extensive work on the ship was required at the beginning of the contract period. In addition to deck remodelling, hull work, engine overhaul and reworking of the electrical and plumbing systems, a number of special support

items were acquired. The latter include a galley refrigerator, a ten foot skiff with motor, ventilation and fire-fighting equipment, items of special engine room equipment, and various navigational and meteorological tools and instruments.

It is necessary that all of the employed crew be Mexican nationals; recruiting the requisite crew for our needs from the small fishing town of Puerto Penasco presented obvious problems, but the outcome has been satisfactory. A skilled fishing boat captain has been employed on contract and has proved to be very capable; we are particularly pleased at the rapidity with which he has acclimated to our scientific program needs. A satisfactory seaman/cook has also been employed and the matter of crew appears to be well stabilized. The bilinguality of most of our scientific staff has been a major asset.

With the deeply appreciated cooperation of the Port Captain of Puerto Peñasco, we have been able to make arrangements for easy and trouble-free movement of the ship "Adventyr" on its scientific work. Special forms have been printed to provide port leaving and re-entry papers for the ship; this has greatly facilitated our activities in Mexican waters. Figures 1 and 2 illustrate a copy of leaving papers for the November cruise.

THIS OBJECTIVE HAS BEEN ACCOMPLISHED.

b. Assess oceanographic needs for the ship; acquire and install the instruments needed.

Program plans call for ground observations through both ship cruises and instrumented buoys (see section e, following). Compatibility between the two ground data acquisition systems is essential. After comparing available in-house instrumentation with the special sensors to be installed in the oceanographic buoys, a Marsh-McBirney 711 current probe was purchased. This instrument, which will measure current speed and direction, is presently being adapted for use on the ship, where it will yield data compatible with the buoy data. All other environmental parameters presently under study can be measured with in-house instrumentation available to the program. The instrument used for measuring salinity, conductivity and temperature may require a more sensitive, digital readout attachment, if future findings indicate the need for greater ground observation accuracy to fully exploit the remote sensing data.

Navigational accuracy and station return capability are especially important in this study. After surveying the available instrumentation and rating all options, an Omega Navigational Receiver Model 1100 was purchased and installed on the ship. Our accuracy for repetitive station location now compares favorably with ERTS-1 resolution and the spatial magnitudes of the phenomena under observation. Unfortunately, a program of Omega station shutdowns for increasing their broadcast power has occasionally hampered our work and may continue to do so during February and March.

Figure 1

UNIVERSIDAD DE SONORA

UNIDAD EXPERIMENTAL PENASCO

PUERTO PEÑASCO, SONORA

AVISO DE SALIDA

C. CAPITAN DEL PUERTO.

Presente.

Por el presente nos permitimos informar a usted que el Yate a nuestra consignación denominado Barco Adventyr del porte de 17.80 toneladas brutas y 5.33 netas zarpará el día 14 de Noviembre con destino ALTA MAR. Via Estudios Cientificos

Su calado a proa y popa es de ______ y ______ Mts., respectivamente.

La tripulación que atiende los servicios del barco será compuesta por el personal que consta en el reverso de este aviso.

Los documentos que anexamos, correspondientes a la salida del barco, son los siguientes:

(7) ejemplares de este Aviso de Salida.

Asimismo hacemos constar que el barco a cumplido con todos los requisitos reglamentarios, por lo que ruego a usted tome nota de la salida de dicha embarcación.

Puerto Peñasco, Son., a 14 de Noviembre de 197

Como Capitán del citado buque declaro que los datos contenidos en el presente Aviso, son exactos, así como de acuerdo con lo dispuesto en el Artículo 29 del Reglamento para la Navegación de Cabotaje, no hay impedimento legal, para que zarpe la embarcación la cual se halla en buenas condiciones de navegavilidad.

El Capitán del Barco

David Cabrera Gonzalez

En atención a que fué nesesario que el buque zarpara en tiempo inhábil para la Capitanía del Puerto, carece este aviso del sello de la Oficina y en cumplimiento de lo dispuesto en el Artículo 24 del Reglamento para la Navegación de Cabotaje, los suscritos, bajo su responsabilidad, autorizan el zarpe de dicha embarcación, en virtud de no haber contravenido ninguna disposición de la materia y en el concepto de que han cumplido con lo dispuesto en el Artículo 26 del citado Reglamento y de que han entregado a la Autoridad Marítima en las tres primeras horas hábiles, los documentos correspondientes al zarpe de esta embarcación.

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Figure 2

TRIPULACION DEL BARCO

No.	NOMBRE	Nacionalidad	TITULO	Cargo que Desempeña	Edad	SUELDO
1	David Cabrera Gonzales	Mex.	Pat. Mot.	el mismo	33	convenido
2	Manuel Salamon	Mex.	Cocinero	el mismo	31	convenido
3	Christina Flanagan	E.U.A.	Biologa	el mismo	23	no tiene
4	Richard McCrory	E.U.A.	Estudiante	el mismo	19	no tiene
5	Antonio Diaz de Leon	Mex.	P. Ocean.	el mismo	20	no tiene
6	B. Primitivo Flores	Mex.	Oceanologo	practicas	26	no tiene
7						
8						
9						
10						

Autorización del Capitán del Puerto

Cap. Alt. Antonio Delgado Amao

c. Proceed with systematic schedule of cruises, making ground observations for analysis and comparison with ERTS-1 data.

During the initial period while the ship was in the Puerto Penasco shipyard for modification and overhaul, a "scientific shake-down cruise" was conducted in August aboard a chartered shrimp trawler. The "Adventyr" was ready for the second data collecting cruise in September and has served for regular cruises since then, with continuing shipyard work between cruises. The ship is now fully operational and, at the time of writing this report, is at sea on the sixth major cruise of the NASA program. Figures 3 and 4 show both surfaces of a Project Summary Sheet from a recent cruise; Figure 5 shows a sample Station Data Sheet.

d. Accomplish engineering design of remote data collection buoys; construct and field test first buoy; modify design as use-tests indicate and construct second buoy.

Figures 6 and 7 illustrate buoy construction and anchoring design. The buoy is an 8' x 10' hollow rectangle of reinforced concrete around a foamed plastic core. It has a draft of 30" with 6" of freeboard, and with a displacement of about 8,000 pounds. The structure is planed on two sides to provide a lift-over-drag advantage during strong currents. A 2' x 6' central well with lock-down flush steel cover will hold the power supply and electronic packages in modular, waterproof containers of fiberglas. The containers will enclose an atmosphere of nitrogen under positive pressure. The water-immersed sensors will be located on the ends of probes extending downward through the center slot to appropriate depths, and will be displayed across the direction of current flow to eliminate interference between them.

The immersion of the packaged electronic components in sea water under the flush steel cover is intended to control operating temperatures and provide protection against accidental damage or vandalism. Since the buoys will be unattended for periods of up to a month at a time, this feature is an important reliability factor. The telemetry antenna and air movement sensors must be exposed on masts approximately 8' above the deck; these are, however, less sensitive to damage and easier to replace than the electronics.

The first buoy was poured in late September and the forms stripped a week later. It was then towed from the shipyard to a location a few hundred yards offshore from the Puerto Penasco Marine Science Laboratory and anchored without electronic payload for a test of its structural integrity and stability characteristics under storm conditions.

About two weeks after anchoring, a storm occurred which had winds above 30 knots over several days. The buoy appeared to maintain fair stability in the high seas, but dragged anchor and eventually grounded on the beach about one quarter mile east of the laboratory. The dragging was due to use of an

FILED BY ____________ PROJECT SUMMARY SHEET DATE 21 December, 1972

**SEE REVERSE SIDE FOR SUMMARY OF UABC WORK.

PROJECT NO. Cruise IV, Dec., 1972 (officially changed to #104)

PROJECT TITLE Study of the Marine Environment of the Northern Gulf of California

VESSEL R/V "ADVENTYR"

INCLUSIVE DATES 9-18 Dec.,'72

NO. OF STATIONS PLANNED 47

NO. OF STATIONS TAKEN 36

LIST OF STATIONS OMITTED A4, A10, B1, B4, B5, B8, B9, B10, B11, B12, B13

STATION MAP ATTACHED Yes

STATION LIST ATTACHED Yes

DESCRIPTION OF PURPOSE & AREA SAMPLED
Test site #324, northern Gulf of Calif., between 31° and 32° N. latitude; for purpose of oceanographic data collection at selected stations in conjunction with NASA Project SR102.
(UA and combined cruises given "100" listings for project numbers, cruises by UABC only given "200" listings.....see "PROJECT NO.", above)

CHIEF SCIENTIST J.R.Hendrickson

CAPTAIN David Cabrera

OTHER SCIENTIFIC PERSONNEL

Richard McCrory	UA
L. Arnulfo Galindo	UABC
B. Primitivo Flores Baez	UABC

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GENERAL REMARKS This was the 5th sequential cruise of the NASA program, counting the 25-27 cruise by UABC only (listed as project no. 201). The cruise had the full complement of planned instrumentation except for the Marsh-McBirney current probe, which is still being adjusted. Parameters measured by UABC, and equipment/methods used, are listed overleaf. The Interocean S/T/C probe 513 blew a fuse and was out of action during a part of the cruise; later, fuse was replaced and probe functioned again. Much bad weather (see log), but cruise otherwise ran as expected.

Figure 3

PARAMETER	EQUIPMENT OR INSTRUMENTS	REMARKS
Salinity/Temp./Conductivity	Interocean 513 probe, 514 readout	Functioned well, except for period with blown fuse
Turbidity	Secchi disk	Read with and without yellow ski goggles; could see slightly deeper without goggles
Turbidity	Submarine photometer	Functioned consistantly
Plankton	½ meter diam. net, #6 mesh, glass jar as bucket	For vertical hauls (where current allowed), used 15 lbs. lead on net ring and lead sheath on bottle. (**see Log for description of changed plankton proc.)
Wind speed	Dwyer wind meter (mounted) (assume accurate to ± 3 m.p.h. for any wind above 5 m.p.h.)	After cross-checks bewteen hand-held anemometer brought by UABC, the ship's mounted Dwyer wind meter, and a hand-held Dwyer meter, used ship meter only
Salinity	Nansen bottles, Van Doren samplers	1meter, 5 m. and 10 m. bottled samples for titration
Phytoplankton	Surface water sample	Lugol's iodine preservative

Univ. Autonoma de Baja California Special Activities

PARAMETER	INSTRUMENTS/METHODS	REMARKS
Salinity	Bottled samples for analysis by by Hytech (Bisset-Berman apparatus	Samples taken from 1 meter, 5 m. and 10 m. by either Nansen bottles or Van Doren samplers
Temperature	Bucket thermometer (surface) Reversible thermometers	
Oxygen	Winkler method	Samples titrated for special stations only (see below); bad weather made titration difficult
pH	Orion pH meter, battery, model 407	Samples measured for special stations only (see below)
Alkalinity	Orion (digital) model 801	Samples measured for special stations only (see below)
(Silicates (Phosphates (Nitrates (Nitrates	Spectrophotometer-Coleman Hitachi model 139	Samples frozen in dry ice for laboratory analysis after return to Ensenada; supply in freezer box good for only about 5 days, had to be replenished mid-cruise

Modifications of UABC Special Stations to fit Major Station Plan

Orig. UABC Atation No. (and coordinates)	Changed to Major Plan Station No.	New Coordinates
1 (31°42.0' N; 114°37.5' W)	*Special station added to major plan	31°42.0' N; 114°37.5' W
2 (31°45.0' N; 114°41.5' W)	D5	31°46.0' N; 114°42.5' W
3 (31°49.0' N; 114°49.0' W)	D4	31°49.0' N; 114°48.5' W
4 (31°48.0' N; 114°48.5' W)	D3	31°44.0' N; 114°48.0' W
5 (31°39.0' N; 114°43.0' W)	D2	31°41.0' N; 114°42.5' W
6 (31°36.5' N; 114°45.5' W)	D1	31°36.5' N; 114°42.5' W
7 (31°25.0' N; 114°49.5' W)	C9	31°27.5' N; 114°48.0' W
8 (31°31.0' N; 114°43.0' W)	C8	31°27.5' N; 114°42.5' W
9 (31°35.0' N; 114°36.5' W)	D7	31°36.5' N; 114°31.5' W
10 (31°39.0' N; 114°29.5' W)	D8	31°36.5' N; 114°21.5' W
11 (31°32.0' N; 114°24.5' W)	C6	31°27.5' N; 114°21.5' W
12 (31°26.5' N; 114°33.5' W)	C7	31°27.5' N; 114°31.5' W
13 (31°21.0' N; 114°42.5' W)	C2	31°18.5' N; 114°42.5' W
14 (31°16.0' N; 114°51.0' W)	C1	31°18.5' N; 114°50.0' W
15 (31°08.0' N; 114°51.0' W)	B13	31°09.5' N; 114°51.5' W
16 (31°15.0' N; 114°40.0' W)	B12	31°09.5' N; 114°42.5' W
17 (31°22.0' N; 114°28.0' W)	C3	31°18.5' N; 114°31.5' W
18 (31.28.5' N; 114°17.5' W)	C5	31°27.5' N; 114°10.5' W

Figure 4

Project No.	Station No.	lat.	sonar depth	wind	temp.	clouds	sea	swell	con. no.	weather
cruise 5	C6	31°27.5'	65 ft.	speed 12 m.p.h.	dry 63.3°F.	type strato-cumulus	ht. 0.5 ft.	ht. 3.5 ft.	30	general, medium heavy overcast
Vessel Adventyr		long. 114°21.5'							visibility 20 mi.	
Date 17 Dec. 72	Time 1430	navig. Omega	Barometer 30.57	dir. N	wet 52.9°F.	amt. 100%	dir. N	dir. NW		

SALINITY-TEMPERATURE-CONDUCTIV.

Instrument Interocean 513	
time in 1440	wire angle 5°
time up 1449	wire angle 15°

Parameters	D1 1m.	D2 5m.	D3 10m.	D4 15m.	D5 20m.	D6 25m.
conductiv.	46.2	46.2	46.2	46.2	46.3	46.2
temperat.	17.4	17.4	17.3	17.3	17.5	17.4
salinity	35.8	35.8	35.8	35.8	35.9	35.8

CURRENT Instrument

Depth	X vector	Y vector	heading	speed	angle	direct
D1						
D2						
D3						

PLANKTON SAMPLING	sample 1	sample 2	sample3	sample 4	sample 5
wire length	10 m.	10 m.	0		
wire angle	6°	7°	—		
type	vert.	vert.	phyto.		

TURBIDITY Instrument Submarine photometer

	wire length	Deck cell	X factor	sea cell
D1	0	5 "	1.0	7.75 7.5
D2	5 10	" 4.75		5.75 3.75
D3	15	4.25		2.4
D4	20	4.75		1.6
D5	25	"		1.0
D6	30	"		0.75

Secchi Disk reading 8/4 = 9

OMEGA Computations

LOP1 B-D reading	
St.1 PPC	see log
St.2 PPC (-)	
Tot. Correct.	
Corrected reading	1026.3
LOP2 C-D reading	
St.1 PPC	see log
St.2 PPC (-)	
Tot. Correct.	
Corrected reading	977.75
Longitude	Latitude

OTHER SAMPLES (Specify)

COMMENTS Galindo & Primitivo will leave ship after this point in cruise

BOTTLE CASTS

no.	time	depth	angle	temp.	samp #	DO	PL	specify	specify	specify	specify
1	1450	1 m.	0°		both for UA						
2	"	10 m.	0°								

Time abandon station 1452

Heading to next station N. To

El Golfo

Figure 5

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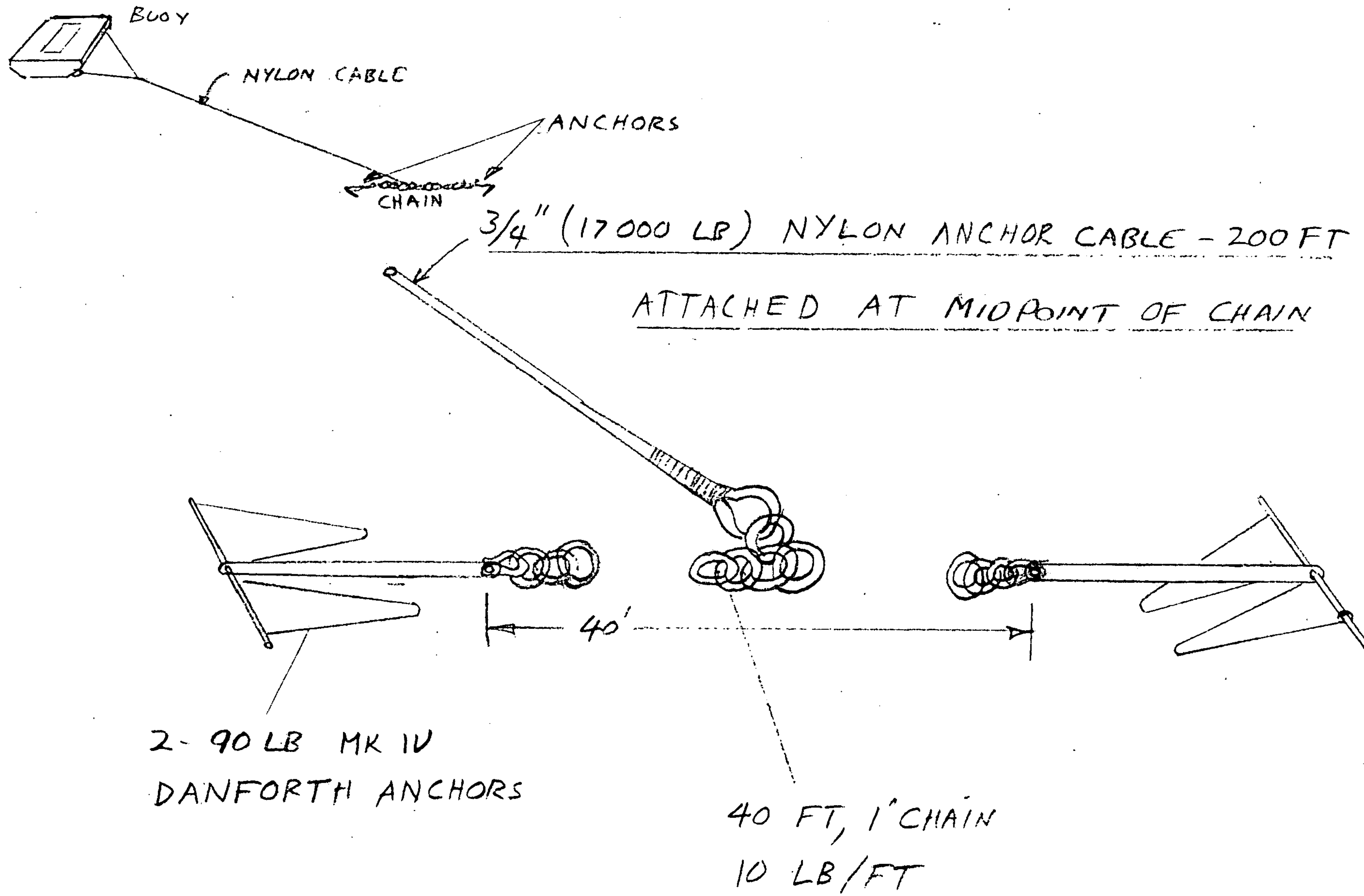

REVISED ANCHORING SCHEME

NASA BUOYS
1/5/73

Figure 7

anchor suited for soft mud, but not for the compact sand at the test location. The lack of sufficient scope in the anchor line was probably a contributing factor.

Attempts to re-float the stranded buoy were limited by tidal cycles (tidal excursions may exceed 20 feet in this area of the northern Gulf), and the first attempt failed because the buoy was so deeply embedded in sand on the upper beach. A second attempt during the spring tide cycle of December 21-22, coupled with prior excavation of the sand, was successful and the buoy was again anchored on station. It was re-anchored with a redesigned anchoring system consisting of two commercial anchors of a type rated for sand, plus a length of heavy chain and more generous scope of anchor cable. It has withstood further heavy weather without further obvious drift, and it is believed that this design is adequate to ensure against further dragging.

In grounding, the buoy passed over a section of rock reef in reaching the beach and considerable concrete was chipped off the bottom surface, exposing flotation foam and reinforcing steel on its underside. Buoyancy does not appear to be significantly affected (actually, it is somewhat more buoyant due to the loss of concrete). Some concern was felt over the exposure of flotation foam and a portion of the reinforcing steel to which the anchor cable is attached. This steel, however, is a continuous loop of which only about one-eighth is exposed and it has been concluded that there is no significant risk of structural failure in a sea way. The inertness of the poly-urethane foam in sea water has been confirmed by independent expert opinion. The general conclusion of the engineers is that the buoy in its present state can meet design requirements.

As a result of the above conclusion, it has been decided to equip the buoy with the first set of instruments and to complete the first phase of equipment testing in its present location. The first full field test should take place during early February.

There are to be six water-tight, fiberglas boxes carried in the central well of the buoy, two for electronic gear and four for storage batteries. This represents a design change from two to four batteries, in response to estimates of power drain higher than those based on original information. Five of the boxes are completed and the sixth will be completed in January. Mounting hardware for the electronics packages is generally specified, but detailed fabrication of many small brackets, clips, rails, etc., remains to be done and can only be completed when certain outstanding orders for electronic components have arrived. Difficulties in locating advertised items and in getting deliveries have delayed a number of serially-related operations including construction features. The gasketing system for sealing the box lids has been successfully tested on two of the boxes; final pressure integrity of the boxes must await the arrival of the water-tight connectors through which interconnecting cables must pass. The nitrogen pressurizing system is planned, but not yet fabricated.

Delivery of the north-seeking device which will reference both current and wind directions has disclosed the need for mounting this in gimbals to

provide required accuracy. The gimbal design is complete but not yet fabricated.

The present schedule calls for all hardware for the first buoy to be complete by the end of January, with final assembly complete by February 5, buoy installation on February 10 and data acquisition thereafter. After approximately one month of satisfactory operation by the first buoy, the second buoy will be constructed.

e. Accomplish electronic systems engineering for remote data collection buoys.

The main body of what follows has been drafted by the electronics experts who have done the actual work, but this section of the report deserves a special preface by the Principal Investigator, who is not himself an electronics expert. At the time of presenting the original proposal for the project, the P. I. depended entirely upon the expertise of a private electronics laboratory, plus information provided by NASA, for formulation of plans and budget relating to the remote data collecting buoys. The P. I. now realizes that he was naive in this section of the proposal and made unrealistic estimations with regard to staffing, timing, and budget for the buoys. After-the-fact assessment of the problems, plus information on other, comparable NASA projects indicates that a burden which might be reasonable for an entire company, with funding an order of magnitude greater than provided, has been placed on one part-time engineer assisted by two part-time technicians who are also full-time university students. The fact that this portion of the work has not only escaped degeneration into a hopeless mess, but has moved through grave trials and pressures to its present level of success topped by unexpected accomplishments in certain areas is due entirely to the total dedication and virtually superhuman efforts of Mr. John Sundberg ably assisted by Mr. Robert Mangum and Mr. Michael Toepper. The P. I., who must personally accept full responsibility for much of the problem, feels compelled to record here his gratitude and his unashamed pride in the way these men have done the apparently impossible. He also wishes to draw to the attention of NASA the exceptional credit due these men for "saving" the situation.

The electronics efforts of the data buoy design were broken down into six areas: 1) Parameter sensor review, acquisition, adaptation and evaluation; 2) Signal conditioning circuitry design, testing and evaluation; 3) Slow speed

multiplex circuit design, testing and evaluation; 4) Period timer and synchronizer design, testing and evaluation; 5) Power supply design and evaluation; 6) Interconnection of the above including cabling between electronic units, assessment of environmental impact of salt water on connectors, and packaging of designed and assembled electronics. As a result of severe manpower shortage, these tasks had to be performed in a series manner rather than the more expedient parallel one which would have been desirable, given sufficient personnel. In addition, discovery of unexpected discrepancies between DCP manual and apparatus, and of DCP and test set design deficiencies, caused delays which were magnified by the series approach.

e-1. Parameter sensor review, acquisition, adaptation and evaluation.

The following parameters were identified as desirable for measurement: Salinity, water temperature, conductivity, current velocity, current direction, turbidity, dissolved oxygen, air temperature, wind velocity, and wind direction.

An exhaustive search of available oceanographic instrumentation was conducted to determine the most appropriate measurement device for each of the desired parameters. Selection of instrument type and manufacturer was dependent upon the following project requirements and guidelines: 1) Capability of unattended, reliable, repetitive measurements for a period of up to 40 days. 2) Capability of measurements within the desired range and of the desired precision. 3) Low susceptibility to fouling by suspended particulate matter and marine organisms. 4) Demonstrable previous success of apparatus under severe field conditions comparable to those of this project. 5) Cost, to allow system acquisition within stipulated budget limits. 6) Delivery time to meet project schedule. 7) Forecast of supplier's ability to service, modify, and consult on use of their product. 8) Signal conditioning requirements for interface with telemetry package. 9) Power requirements.

Displayed in Table 1 is a listing of the parameters and associated specifications for which the buoys are to be instrumented. Table 2 shows instruments chosen. Discussion of the parameters and instruments follows below.

Temperature-Conductivity-Salinity: It was decided to measure conductivity and temperature on a single inductive instrument, using computer software to convert temperature and conductivity to salinity, as well as tabulating the temperature data separately. The most accurate method of measuring conductivity is to induce a field, using AC, into the sample volume of water. The current flowing in another loop will be proportional to the conductivity and with proper electronic techniques can be converted to a DC voltage which is applied to the DCP. Interocean Systems was found to have a rugged probe which has no moving or exposed parts and their Model 513 was selected to measure temperature and conductivity of the water.

Yellow Springs Instrument thermolinear thermistors will be used to measure air temperatures and water temperatures (redundant instrumentation for cross-checking the Interocean probe). These devices use several thermistors in a composite to obtain a linear voltage output with temperature.

Table 1

	Oceanographic Parameter	Range	Accuracy	Comments
1.	Water temperature, 1m. depth	11° - 35° C.	± 0.2° C.	Depending upon where buoy is anchored, may want 3m. and 5m. depths also.
2.	Salinity, 1m. depth	33 - 39‰	± 0.1‰	....
3.	Conductivity, 1m. depth	0 - 65 millimhos	± 0.05 millimhos	Not primary measurement; for correlation with temp. to calculate salinity.
4.	Current velocity, 1m. depth	0 - 10 knots	± 0.2 knots	Accuracy figure may be negotiable.
5.	Current direction, 1m. depth	360° revolution	± 5°	....
6.	Turbidity, 1m. depth	0 - 25 ft. visibility	?	Accuracy constraint wholly dependent upon sensor specs.
7.	Dissolved oxygen, 1m. depth	0 - 8 ml./liter	± 0.2 ml./liter	Accuracy constraint indicated is desired, but must remain dependent upon sensor specs.
8.	Air temperature, 1 - 2 m. above sea surface	-2° to +45° C.	± 0.2° C.	Exact height above sea surface dependent upon engineering factors.
9.	Wind Direction, 1 - 2 m. above sea surface	360 revolution	± 5°	Exact height above sea surface dependent upon engineering factors.
10.	Wind Velocity, 1 - 2 m. above sea surface	0 - 70 knots	± 2.5 knots	Exact height above sea surface dependent upon engineering factors.

Table 2

Parameter	Manufacturer	Model
Temperature (both water and air)*	Yellow Springs Instrument	Model 701; Model 705
Salinity (via temp. + conductivity)	Interocean Systems	Model 513
Current (velocity and direction)	Marsh-McBirney	Model 711
Turbidity	Monitor Technology	Model 2-350
Dissolved Oxygen	Weston and Stack	Model 3000-1-A with A40 probe and A25 agitator
Wind Direction and Velocity	Bendix	Model 120
Compass Direction (for correcting both current and wind directional readings to true compass readings)	Humphrey	North-seeking device NS 04-0301-1

* In addition to the Interocean Systems probe measuring temperature and conductivity for salinity calculations plus direct temperature readout, there will be a redundant temperature probe used in the water.

Measurements of current velocity and direction must be made with a static device because of the high levels of suspended sediment in the water where the buoys are to be placed. The moving parts of impeller devices would become fouled in a short time. The Marsh-McBirney sensor selected uses an electromagnetic induction principle and produces two orthogonal components of water flow perpendicular to the longitudinal axis of the probe. Computer software will convert this data, plus information from a north-seeking device, into true direction and speed.

The north-seeking device uses a magnetic compass attached to a potentiometer. The output is proportional to the resistance, which in turn is a function of direction referenced to magnetic north.

Turbidity measurements present a special challenge in the environment to be studied, where Secchi disk visibility may vary from 1/2 inch to 35 feet. A unit is needed which is capable of operating when fouling is present and which is capable of measuring very high particle levels. The Monitek unit selected uses two light sources and a forward-scatter technique. It compensates for ambient light and for lens obscuration up to 50%.

Dissolved oxygen measurements are particularly difficult to make with unattended apparatus, and the extreme marine environment concerned here compounds the problems. The Weston and Stack model selected has been proven in severe environments. Built into the probe is an agitator which can be adjusted to wipe the membrane if fouling becomes a problem.

Wind velocity will be measured by an impeller instrument with a good history of use on oceanic buoys. A DC generator will be employed along with a synchro output for direction. This direction will be referenced, as for current direction, to the north-seeking device and computer software will provide true direction.

e-2. Signal conditioning circuitry design, testing and evaluation.

Burr Brown 3500 A operational amplifiers form the nuclei of the analog channel signal conditioning. They are improved versions of the 741 type operational amplifier and it was felt that, since slew rate, low input bias current and most other critical parameters of the operational amplifiers were not very stringent, these amplifiers should suffice. They have excellent minimal drift characteristics, which was the basic reason for selecting the 3500 type. Various restive networks are needed in conjunction with the operational amplifier circuits for matching the circuits of the potentiometric North Seeker and thermistor composites, and for dividing down those outputs which are higher than 5 volts so that the operational amplifier can be used to give 0-5V output for the range of each sensor. Test circuits were designed and put into a prototype unit for testing of drift due to temperature and time. They provided excellent performance.

Since the wind direction sensor is a synchro-transmitter, a synchro-to-DC converter had to be found and this made necessary a sine wave inverter in the power section. This type of problem came up repeatedly, as most of the equipment available is designed to run off of 60 hz mains. AC operation

could probably have been eliminated altogether, but the lead time for redesign of these circuits made this impossible.

e-3. Slow speed multiplex circuit design, testing and evaluation.

As the number of parameters to be measured exceeds eight, it was necessary to develop a system to increase the capabilities of the DCP. Since the location of the buoys is well situated for rather long acquisition times to Goldstone, it was decided to decrease the DCP timing period to 90 seconds rather than the standard 180. Then, by switching between two sets of eight sensors each, the capability could be increased to 16.

It was decided to use the data gate signal to trigger a Flip Flop which in turn would activate relays and select the proper channels. Our first problem occurred when it was found that no data gate was present on the analog plug of any of the three DCP's we have. The manual with its wiring diagram showed this signal to be available at the analog plug. It was available at the test plug, however. Now, since no power is applied to the hex inverter which supplies the data gate except during the approximately 80 ms. of the power up-time, noise was present on the line and the output of the data gate had to be clamped to 5V (keeping in mind the current sink capabilities of the data gate inverter) to make it function as a proper logic circuit. In our opinion, it would have been desirable to have designed the DCP to keep this circuit energized, even if low power logic had to be used.

After completing the first prototype of the Multiplex, it was still being toggled at some point in the middle of the power-on cycle. This meant the circuit toggled when the data gate first appeared and then again half way through the power-on cycle. A storage scope was used to determine exactly where the problem was occurring and it was found that a positive going spike appeared when the transmitter was pulsed. A regulated supply of enough current capability to provide for the peak power was being used, demonstrating that the regulation within the DCP must not be adequate. A circuit was designed using a NE555 IC timer which is energized at the appearance of the data gate. The output of this circuit provides a positive level to the Flip Flop (edge triggered) to prevent any further transients from affecting it. Since it is unaffected by any pulses during its timing cycle, which was set for ten seconds, the Multiplex is held in one position until after the data gate is unpowered.

This effort required some time, as a storage scope was difficult to obtain and, until we used one, we did not know it was the DCP causing our problem.

The Multiplex uses solid state relays which eliminate contact bounce, coil kickback and give excellent time response. The technique of locking out the input for a pre-determined time to suppress noise was not seen in a search of the literature, but that is not saying that it has not been used previously by other users.

The Multiplex circuit was bench tested over a 72 hour period using a DCP and gave excellent results. It was also tested in a roof top installation

at the University and data was received for a ten-day period from the receiving sites.

Since the overall DCS system has not been studied in depth, system interference may result in some locations, but it seems that an even shorter time period than 90 seconds could be used to obtain still more data. On an individual basis, this could be advantageous to some users.

e-4. Period timer and synchronizer design, testing and evaluation.

The design philosophy for the circuitry of this device changed several times due to the designers' lack of knowledge of orbital mechanics.

The need for the timer arose because of limitations on the amount of electrical power available on the buoy. Some method was needed to turn sensor and electronic devices off when the satellite was not in view of Goldstone, and possibly Goddard.

The first scheme was to turn on power when the satellite crossed the latitude of Goldstone. (Actually ten minutes before, then keep power on for 20 minutes.) This was to be done every orbit using a timer having the period of the satellite as its base. It was originally thought this would give transmissions on all usable orbits day and night. The time on would then be about 280 minutes per day. This circuit was built and tested and did indeed perform its electronic function as intended. However, further thought on the subject made the designers realize that only the AM orbits would be usable, as the useful PM orbits are ascending ones and a timer synchronized to the satellite descending over the buoy would not give the desired results.

Some thought was given to having an AM and PM timer and turn on every ascending and descending orbit, but the power-on time would be too great. The next design was for a complex timer to turn on for the first usable AM orbit, be on for 20 minutes, turn off until the next one, and repeat this cycle for three orbits AM. Then power would be off until the PM orbits and the cycle would repeat. For day N + 1, the turn-on time would change by approximately six seconds and after 18 days, everything would reset. It was decided that this circuitry was more complex than the whole buoy, and it was therefore discarded.

The final solution, which fortunately is rather straight-forward, is to use a period timer and gate its output with a comparitor whose output comes from a GMT-based 24 hour clock circuit. Two outputs are available from the clock circuit: 0900-1200 and 2100-2400 local time. This insures only the orbits that can be used will have power turned on. No day to day changes have to be programmed.

The timer circuits use a Motorola temperature compensated crystal oscillator which has a stability of better than one part in 10^6 per year over a temperature range of 0^{o}-50^{o} C. The power consumption is only 250 mw. The divider circuits are comprised of low power 7400 logic and the output of the solid state twenty minute timer activates a solid state relay capable of switching the entire load.

The second buoy will use CMOS circuitry to reduce power to a still lower level.

The AM portion of the timer has been built in prototype form and transmissions have been received by Goddard and Goldstone so the design philosophy has been implemented successfully.

e-5. Power supply design and evaluation.

As mentioned previously, 115V. 60 hz power was needed for operation of some of the sensors, as DC option power supplies would have taken too long to obtain. An added requirement was the need for sine wave excitation for the synchro in the wind direction sensor. A sine wave solid state inverter was decided upon for all AC needs.

The DC-DC converters needed for the remainder of the electronics are solid state modular types obtainable as off-the-shelf items.

e-6. Interconnection

A very difficult problem to solve was the connector selection for the interconnection of the battery boxes and electronics boxes. Since it was not necessary to disconnect or connect the cables underwater, and since the connector would not be used at any appreciable depth, specialized underwater connectors were felt to be too expensive. In addition, they are inconveniently bulky. Since most connectors use aluminum for the metal parts, great care had to be taken to obtain ones having a finish capable of withstanding salt water immersion. Bendix QWLD series connectors were specified; it is felt they are adequate for the environment, yet do not have features not needed.

No facility exists in the Biological Sciences Department for printed circuit board design or fabrication, but it is felt this type of circuit construction is necessary for a professional product. The art work and actual fabrication of the boards will be done locally in cooperation with the design engineers as a purchased service.

Some delays were encountered due to problem areas with the GFE items. The test procedure as written in the manual is inaccurate and it seems we are the first and possibly the only user to bring this to the attention of General Electric (the fabricators).

The voltage in the field test set is too high and as of this date no modification kit or instructions have been forthcoming from GE. This is a small design change, but the test set cannot presently be depended upon to give accurate checkouts, as the logic buss voltage exceeds the specs for the logic being used. Time has not been available as yet to design and add a voltage regulator to the test set.

An antenna test was performed at sea after the electronics portion of this report was drafted, and it is felt this should be covered briefly. Some concern was felt over the possibility that wave motion at sea would cause the

antenna angle of radiation to change, resulting in loss of transmissions; since a Multiplex is used, this could cause loss of half the data. The DCP was kept on the service boat, the "Adventyr," and a coax transmission line was attached to the antenna mounted on the buoy. All transmissions were received in sequence on January 13, 1973 at approximately 1719-1734 GMT with a buoy/antenna motion up to 30°. It is acknowledged that this is not a good statistical sample, but if buoy motion proves to be a problem, a gimbal system will be used on the antenna.

The present schedule calls for final packaging of all electronics in the watertight boxes by February 5, followed by final "dry" testing before installation in the buoy on February 10 and data acquisition thereafter.

We wish to emphasize that a development program of this complexity should have been of longer duration and employed more technical personnel. The job functions of circuit designers, systems designers, test engineers, specification engineers, sensor designers, packaging engineers, coordinators and purchasing agents have been concentrated in three people, as far as the electronics go. It is hoped that no crucial areas have been overlooked.

2. Coordinate Field Research Activities with Mexican Cooperating Institutions.

a. Obtain clearance from Government of Mexico for plane overflights.

Clearance for plane overflights, applied for through official channels, was refused. Therefore, portions of the program dependent upon overflight data (analyses involving thermal I. R. data; analyses of fishing intensity) have been dropped, as indicated in the Data Analysis Plan filed on Jan. 12, 1973.

b. Obtain clearance from Government of Mexico agencies and from local port authorities for surface activities of U. S. personnel, ship and buoys.

Necessary individual permits to conduct investigations in Mexico have been obtained for the principal U. S. persons involved. These permits are issued for one year at a time. The permit renewals for 1973 (requested in Nov., 1972) have not yet been received in the mail from Mexico, but this is normal; we have been assured that there is no cause for concern and that we should continue to use our old permits until the new ones arrive. This has been the routine practice in previous years.

Clearance for ship movements has a special context for this program. Firstly, because our research vessel "Adventyr" is Mexican-registered in the name of the University of Sonora, we encounter few of the complexities met by foreign-registered ships. Secondly, because the ship is under the control of our U. S.-based program, we give special attention to communicating with local port authorities to avoid confusion and inconvenience. As described in the final paragraph of section 1-a of this report, specially-printed sailing forms have been prepared in consultation with the port authorities, paralleling standard Mexican proceedures for local fishing boats. This system of port-departure and port-return sailing papers is working perfectly.

Placement of our instrument buoys in Mexican territorial waters requires further special arrangements. The buoys will be registered on our behalf by the Department of Oceanography of the Mexican Navy. An official description of the buoys and their planned deployment has been transmitted to the Director of the Department, who is also one of our cooperators and standard data recipients; he informs us that the description has gone to press and will be published in the January, 1973 issue of "Aviso a Los Marinos" ("Notice to the Marine Police"). This issue will be distributed in February (normal scheduling). The local port authorities in our area of investigation have been individually informed in advance, and are cooperating with us in every way. Cooperation has included ad hoc permission for test anchorages, permission to occupy the intertidal zone of Puerto Penasco harbor during construction of the first buoy, and permission to beach the buoy at preferred locations in the busy harbor for inspection and installation of fittings; it will include volunteered special diversions of marine patrols to establish

the official status of the buoys and to discourage possible vandalism.

c. Formulate a master plan of oceanographic research together with participating Mexican research institutions, including agreed plans for work-sharing, data exchange, mutual assistance, and general exchange of ideas.

The National Council of Science and Technology of Mexico has given much organizational assistance and is presently identified as the official deposit point for data generated in this program, serving the country in general. The Council contributes no working scientists to the program, but has funded a full-support scholarship for one graduate student presently working toward a Master's degree on the Tucson campus, working on interpretation of the ERTS-1 imagery of our area.

The Department of Oceanography of the Mexican Navy has released one of its officers to study in our program under the above scholarship; as mentioned above, this Department is another standard data recipient in our program, and they look forward to dispatching one of their ships to work with us in our area to perform special tasks for which we are not equipped (current studies by radar drogues, deep sediment samples, etc.).

The National Institute of Fisheries has been unable to spare working scientists from their limited staff, but remains an interested supporter with serious interest in seeking practical applications of our data when this is compiled. The Institute also serves as our principal agent in the rather complex business of soliciting individual investigation permits within the central Government.

The National Agency for External Space lends valuable support and approval to our program, is a standard data recipient, and hopefully may yet send a second graduate student to this campus to participate in imagery analysis.

The National University of Mexico has undertaken working shipboard participation in our program (which makes them automatically a data recipent). In coordination with the rest of the working scientists in our group, they will undertake 1.) special studies of primary productivity; 2.) distribution of heavy metals in northern Gulf organisms; and 3.) seasonal distribution of commercial shrimp larvae in our area.

The University of Sonora has limited staff in fields related to this project and to date has not identified individual scientists to undertake particular working tasks in the field. They are, however, our most important single participant by virtue of allowing use of their ship for the project and undertaking all manner of other activities to facilitate the work. They are a standard data recipient and are presently considering the possibility of special studies of the near-shore land areas in the ERTS-1 imagery (land development, hydrological, and geographical studies).

The University of Baja California, through its well-developed Institute of Oceanography, is our most active, direct partner in field research. Their staff of qualified oceanographers and biologists, supplemented by a rota of chosen, higher division students, play a strong part in shipboard work and contribute important skills and equipment to the project. UABC has modified an earlier program of studies in the northern part of the area to convert to our standard oceanographic station plan and one station has been added to our original grid to complete the accomodation. At this critical group of 18 stations near the mouth of the Colorado River, UABC measures dissolved oxygen (our plan calls for this from the buoys only), pH, alkalinity, and dissolved nutrients. Over the remainder of the grid, their personnel aboard ship assist in all our standard measurements and add deeper water samples (Nansen bottles and Van Doren samplers) to our measurements of the more superficial waters. They have reorganized their raw data forms to permit easier accomodation to our computer software so that a significant expansion of our data coverage will be possible.

UABC receives a special set of water samples from each cruise for laboratory determination of salinity as a valuable cross-check on our own measurements . All plankton samples are taken in duplicate and UABC takes one set for analysis of macro-phytoplankton, while we have responsibility for macro-zooplankton and micro-phytoplankton analyses. Analysis of sediment samples by UABC has begun and will, subject to available ship time on station, become more important in the future. After assessing relative expertise in our group and the UABC group, they have agreed to undertake at our request systematic bathymetric mapping tasks which are projected for the spring of 1973. UABC is also attempting to organize a data collecting system on fisheries activity in the northern Gulf which would be extremely difficult for us to manage; hopefully, this may offer at least a partial substitute for our original plan of using remote imagery to study fishing intensity and fishing success in relation to environmental parameters.

Appendix A is a record of our first international coordination meeting. It demonstrates well the extent to which we are working together for mutual advantage and the progress of NASA program UN-603.

As a result of increasingly satisfactory experience in working together, the UABC and U. of Arizona scientists are now seriously considering an intensified plan of cruises in which UABC may undertake principal responsibility for cruises alternating with the present quasi-monthly schedule, thereby ensuring ship work at sea on every critical satellite imagery pass (every 18 days) instead of the present pattern of every other pass (every 36 days). While highly desirable, the U. of A. could not undertake such a doubling of effort by itself.

In summary, with the notable exception of overflight permission, we have received enthusiastic cooperation from all Mexican authorities and institutions; we feel that in this respect the program is solidly established on an ideal working basis.

3. Develop Systems and Facilities for Receipt, Processing, Storage, Retrieval and Dissemination of Ground Observations and Specimen Samples. Analyze and Disseminate Data on a Regular, On-Going Schedule.

The receipt, processing and analysis of ground observations and specimen materials, and the subsequent use of the data in interpretation of ERTS-1 imagery must, because of the general objective of the investigation, receive continuing emphasis as the logical means of achieving quantification of seasonality in the northern Gulf of California. Collection of ground observations and specimens by University of Arizona scientists and scientists from two institutions in Mexico has broadened the scope of the data handling phase, both in quantity and quality. The elements of this international cooperative effort are dealt with elsewhere and discussion here is limited to the work on management of data and materials after collection.

Although not specifically anticipated in the original conception of this phase of the investigation, the need for a central data dissemination and control library was soon recognized, since data from up to four distinct sources is possible. These include the University of Arizona monthly hydrographic cruises, the U. of A. oceanographic buoy data collection platforms, Universidad Autonoma de Baja California hydrographic cruises, and Universidad Nacional Autonoma de Mexico hydrographic studies. While the cooperating Mexican scientists bring with them objectives in data collection some of which are not central to this investigation, their efforts serve to provide desirable additional sampling which would be impossible for our own scientific party to undertake due to limitations in time, investment, equipment, and talent.

In consultation with the other contributing scientists, the U. of A. has established a central facility for data storage, dissemination and analysis. This facility serves to promote two functional aspects of the cooperative scientific effort: Firstly, a central facility ensures that all data will be freely exchanged between all parties on an indiscriminate and regular basis, and that the results of data analysis will also be automatically available to all parties. Secondly, collection of data on a cooperative basis requires careful planning and coordination among the participating scientists; the data library and establishment of a regular schedule of dissemination of results and raw data serves to stimulate attitudes of cooperation and creates avenues of communication.

Presented as Appendix B of this report is a copy of our "Handbook of Data Acquisition, Storage, Retrieval and Analysis," prepared for use by the scientists participating in this investigation. The Handbook outlines the objectives and activities of the central data facility and provides guidelines for the submission of data to the library. In actuality, the Handbook is an internal proposal in itself, for the activities and mechanisms for accomplishing efficient acquisition, processing, storage, retrieval and analysis had to be generated as a part of this investigation. Our progress toward that goal is presented below.

Activities of the data library include archiving of raw data in a standard ADP format for later dissemination and analysis, spatial analysis

of the data for each cruise for generation of isothermal, isohaline, and comparable distributions, temporal analysis for establishment of cyclical phenomena, and comparison with all available previously recorded oceanographic data from the test area. In particular, the library should in due course provide special analyses suggested by, and for comparison with, ERTS-1 imagery evaluations.

Programs for the initial archiving of raw data have been completed. The format is based on that used by the National Oceanographic Distribution Center and follows their specificiations for coding of standard meterological observations. The algorithm for spatial analysis and mapping of characteristic distributions is in the process of debugging and should be completed by the 25th of January. This algorithm will map horizontal distributions and will not have the capability for vertical profiling; an algorithm for vertical profiling is planned as the next step and will hopefully be generalized for application to the output of the oceanographic buoy data collection systems (key variable depth being replaced by key variable time to generate diurnal profiles in selected parameters). Once perfected, the horizontal mapping algorithm can be used very rapidly to generate maps for all five cruise records currently in the data library.

Temporal analysis algorithms are still in the planning stage and research with respect to this approach is continuing. In addition, the variation in spatial resolution among the various data sources, and with respect to the older oceanographic data currently on file with NODC, will present some problems in temporal analysis. The extent of these problems is not yet known, but they are identified as matters for future attention.

Because of the part-time status of our personnel in this area, coupled with requirements for interfacing with NODC formats and with our own electronic processing and signal design problems, we are behind schedule by about 30 days. This has deprived the interpreters of ERTS-1 imagery of data on which to base analysis decisions and form conclusions. It is hoped that this situation may be remedied by providing spatial analysis maps from the first six cruises by the 31st of January.

Our system now provides for automatic distribution of duplicate salinity samples and macro-plankton samples to both UABC and the U. of Arizona. Salinity is cross-checked at UABC by electronic instrumentation, at the U. of A. by titration; plankton is analyzed at UABC for macro-phytoplankton biomass and species distribution, at the U. of A. for zooplankton biomass and species distribution. Data from these analyses are expected to begin arriving at the library by about March 1. Lugols-preserved samples for microphytoplankton analyses are also archived at the U. of A. and are being analyzed there. It is still uncertain when this data may be expected to begin coming in to the library. Sediment samples, bathymetric recordings, and other types of materials have yet to accumulate in any significant quantity.

The library has begun to function at the data storage and dissemination level. Three sets of computer printouts of raw data have already been disseminated. Within 30 days, the library should have begun to function at the

analysis level and will expand its function thereafter as the types and numbers of analysis algorithms increase. The recent addition of another part-time data analyst should assist in the rapid correction of our present 30 day retardation status.

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4. Prepare For and Conduct Analyses of ERTS-1 Remote Imagery

Lt. Gustavo Calderon of the Mexican Navy, Department of Oceanography, arrived on campus in August, 1972 and began training in imagery analysis under the direction of Co-Investigator Lepley. Lt. Calderon is enrolled as a graduate student on scholarship from Mexico's Consejo Nacional de Ciencia y Tecnologia (CONACYT). His degree research will be on analysis of ERTS-1 imagery of the northern Gulf of California as an integral part of this investigation. His past experience in oceanography, together with a special course in photo-interpretation taken in Mexico and other work abroad (including studies at Scripps Institution of Oceanography) made Lt. Calderon a fast learner who rapidly developed the requisite expertise in this part of our program.

There were initial delays in receiving ERTS-1 imagery from our test area, but this material is now arriving regularly. The analyses described in this report were done without benefit of data from the ground observation portion of this program because of the set-back in computer operations which has been described. There was, however, some a priori knowledge of oceanographic characteristics to aid in interpretation of the imagery. For example, in a model derived from marine optical data collected by Scripps Institution (older instruments) a laminar wedge of clear water overlies a bottom-lying wedge of very turbid water. Tidal excursions in the Gulf are great, ranging up to more than 20 feet between low and high tides at certain times. The Colorado estuary has a very shallow gradient, and tidal currents are extremely rapid. Another factor to be considered is the present lack of outflow of Colorado River water, which has been intercepted by reservoirs and irrigation projects.

Three data clusters, 7 August, 24 and 25 August, and 11 and 12 September were analyzed for three purposes: 1.) to determine the number of oceanographic events and parameters that could be mapped without synoptic surface truth; 2.) to accomplish interpretation training and instrument familiarity; 3.) to pinpoint critical locations for oceanographic surface truth during coming oceanographic surveys.

The optical properties of water are well known and the decreasing depth penetration with increasing wave lengths through the four MSS channels was used as a sounding device to give a three dimensional picture of current structures. Of course, it must be kept in mind that this sequence of penetration breaks down in the very turbid waters, where band 5, the red band, would be expected to show maximum penetration.

Tidal stage during the first two of the three overpass clusters was mid tide following low tide; the third overpass was near low tide.

Cloud patterns were seen which in certain cases were probably due to water surface temperature anomalies. A charted shoal was identified from its disturbing effects on otherwise smoothly laminated layers of turbid and clear water. Gyres in which major circulation of the Gulf appear to be counterclockwise were seen in the last two of the series; this contradicts

what little data is available from previous current measurements in open water, but conforms with theoretical models and comparable situations in the North Sea and the Adriatic Sea; it also corresponds with the orientation of large megaripples along the eastern side of the extreme northern portion of the Gulf. Of great interest in this desert area are sites of possible ground water flow into the Gulf; it is suspected that these are short-term phenomena which appear and disappear at irregular intervals. One site on the present imagery suggests such an occurrence; its location conforms with the location of known shallow wells on the shore.

Analyses of the three data clusters will now be described in sequence through reference to false-color-enhanced video-densitometer images constructed with Spacial Data Model 704/8 equipment of the Arizona Regional Ecological Test Site. Color contours indicate relative grey tone values in the ERTS-1 imagery. The color sequence runs from white at the off-scale portion of the bright end of the grey scale to black at the off-scale portion of the dark end, as follows: white; dark blue; light blue; green; yellow; brown; red; magenta; black. As a general, but not absolute rule, the sequence from white to black corresponds with a range from very turbid to clear water. Because cost factors indicated against using larger-sized color photographs, or more photographs for purposes of illustrating this report, some of the features mentioned and clearly visible on the video screen or the black and white imagery may not be obvious on the illustrations here.

August 7: 1015-17442 and -17445 * (Figure 8)

The tide was at mid-stage and rising. An inrushing tidal wedge of surface water can be seen as blue spears pointing up into each estuary on band 7.

The shoal shown on U. S. Hydrographic Chart #620 at 31°20' N., 114° 35' W. Corresponds to a turbid streamer (brown on band 6) and a trailing plume of clear water (yellow on band 6) in the direction of tidal flow at 31°30' N., 114°45' W. This effect is thought to be due to disturbance of the bottom layer of turbid water by the clearer wedge of water overflowing the shoal and creating a standing wave.

The black seen in bands 5, 6, and 7 may represent downwelling of the clearer surface water. Consag Rocks can be seen on these frames of the original imagery, marking the location of the associated deep waters of Wagner Basin; the black window does not conform spatially with Wagner Basin, despite local fishermen's belief that the waters are most clear over the Basin. It is interesting to note in passing that the

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* Where two sequential frames from the same orbit are available, these are combined to form a two-piece mosaic. The upper and lower halves of the mosaic in Figure 8 were taken at 1744 hours, GMT on orbit number 1015, during a period of approximately one minute.

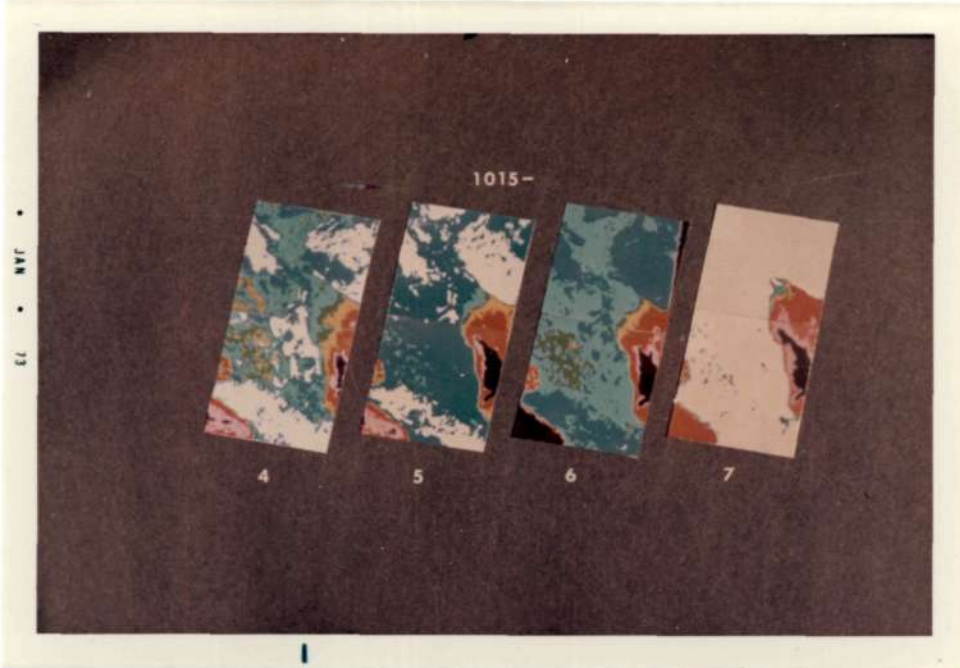

Figure 8

Figure 9

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eastern and western margins of the window shown as black in Figure 8 seem to correspond roughly with the linear areas where most sardine schools are sighted in this portion of the northern Gulf.

At about 31°30' N., 114°05 W. in band 5 of figure 8, a short distance off the northern shore, a small brown plume may be seen contrasting against the surrounding yellow contour. This may indicate a submarine spring off the Gran Desierto. The location conforms with the location of known shallow wells on shore. Imagery from a more recent orbit, not discussed in this report, also shows this plume.

August 24, 25: 1032-17391 and 1033-17444(Figure 9)

The tide was at mid-stage and rising. Northwest-flowing tides can be seen as spears of water (blue color) intruding into estuaries in band 6 of orbit 1033. Superposed over the northwest tidal streamers are a surface turbidity sheet running in a north-south direction (green contour in band 7 of orbit 1033). This sheet seems to emerge from the north shore of the Gulf and move in a southerly direction, indicating a wind blowing from north to south which pulled up turbid water in the north and caused a downwelling of the clearer (black) surface layers to the south. Cloud positions coincide with a western edge of this north-south surface turbidity layer. This cloud streamer is presumed to mark the western edge of the south-moving air mass.

In orbit 1032 a gyre, shown best by longer wave lengths seems to be indicated by a turbidity pattern of rotary surface currents moving in a counterclockwise direction around an eye at 31°00' N., 114°10' W. The gyre has a diameter of approximately 40 nautical miles (green in bands 5, 6 and 7).

The shoal mentioned previously is again indicated by a northwest turbidity streamer.

September 11 and 12: 1050-17385 and -17392 (Figure 10); 1051-17443 (Figure 11)

Tidal stage is 1 1/2 hours after low tide. Bands 4 and 5 of Figure 10 show northwest-southeast streamers indicating tidal directions in deeper waters, and bands 6 and 7 show an abrupt turbidity boundary running north-south at 114°00' longitude, extending to the surface to the west of this boundary. The counterclockwise gyre is seen again in this imagery, as a large yellow mass curling eastward in band 5, with the eastward margin of the gyre marked by clouds (white against blue field in band 6, yellow against brown field in band 7). The clouds indicate possible surface temperature contrast at the eastern edge of the gyre. The gyre has a diameter of about 60 nautical miles, with its eye at 30°40' N., 114°30' W.

The image of September 12 (Figure 11), also shows a tidal turbidity front with a sharp north-south edge at 114°30' W. in all bands. North-south streamers from the north coast can be seen in band 7, indicating surface effects of a wind blowing from the north.

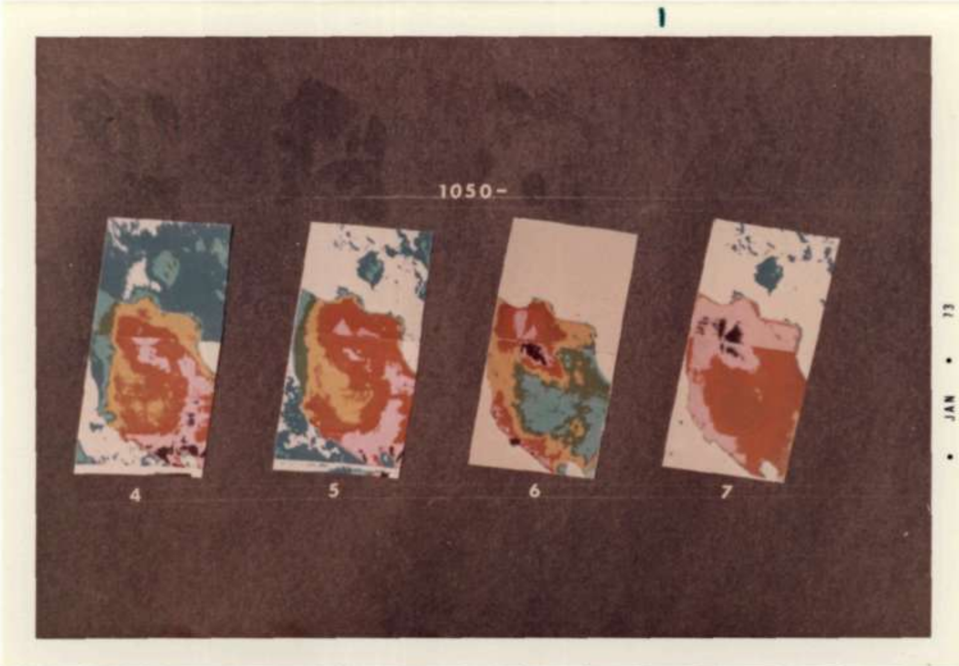


Figure 10

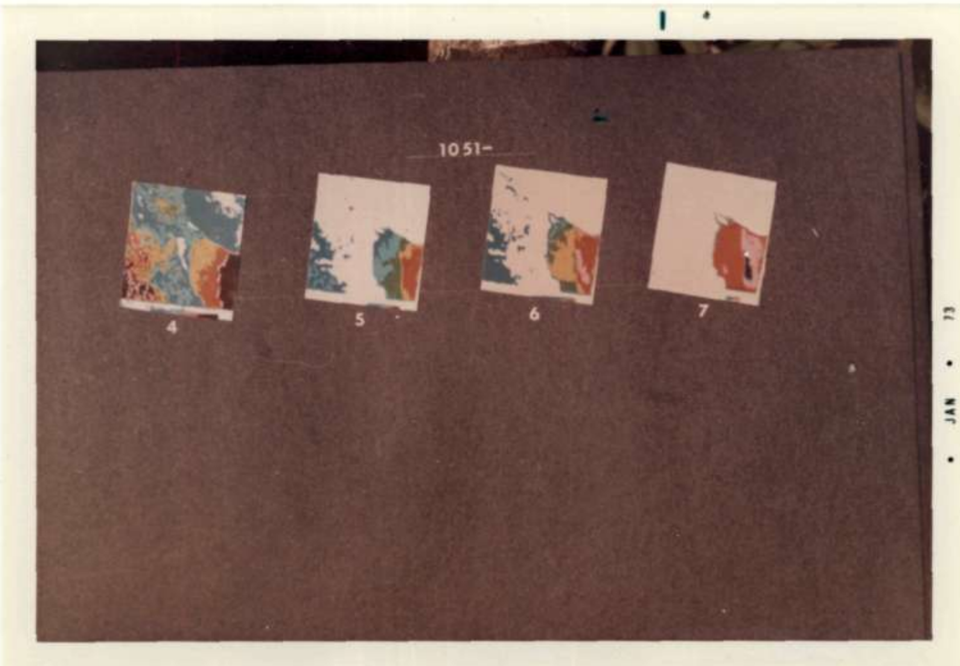


Figure 11

Summary

From ERTS-1 imagery alone, previous to correlation with contemporary ground observations, a number of oceanographic phenomena were observed which were not previously known: 1.) counter-clockwise gyres; 2.) thermal boundaries at gyre edges; 3.) turbidity tracers indicating positions of submarine shoals; 4.) regions of possible downwelling; 5.) suspected submarine spring; 6.) wind effects through turbidity traces.

From the present onward, each oceanographic cruise will include special inspections of sites identified as particularly interesting by the imagery analysts,attempting to provide hard data for correlation with imagery, test hypotheses, etc. The "Adventyr", now at sea, has several such assignments for the present cruise.

The video densitometer results indicate that the darkest half of the ERTS grey scale is needed for oceanographic interpretation of open water, the brighter half for interpretation of exposed land areas above water level and for very turbid waters.

New Technology

1. Buoy Design

The concept of using poured concrete around formed plastic is believed to be a novel idea in its application to moored, instrumented buoys. Conventional instrumented buoys are of welded steel and are significantly more expensive than the design herein described. We think of our buoys as "poor man's buoys" which can be constructed by almost any group for their own use without resorting to specialist subcontracts. Ferro-concrete vessels are well known, of course, but a conventional hollow concrete hull is generally much thinner and contains vastly more steel. The design illustrated in Figure 6 is made by pouring a very fluid mix of rich concrete into plywood forms around a pre-placed core of poly-urethane and pre-placed reinforcing steel which consists of rectangular mesh wire of the type commonly used in concrete floors plus a loop of round reinforcing rod on each side, projecting through the surface of the concrete at each end to provide attachment points for anchor cables.

Another novel feature is the provision of a steel-lidded central well in which are placed fiberglas-plastic boxes housing instrumentation, electronics, and batteries. This arrangement ensures temperatures close to ambient sea water, protects the vulnerable gear from external damage including vandalism (even rifle bullets from passing boats, which is not an uncommon occurence), and still permits servicing by replacement of individual packages.

The cost of materials and construction labor for the buoy described here was under $1,000 (not including cost of engineering supervision or of the re-usable forms). The cost of the fiberglas boxes, sealing and mounting hardware will vary with the design and number of boxes used, but will be between $1,000 and $2,000 for materials and labor.

Still another novel feature of the design is the method of accomodating anchorage in currents up to 10 knots. In most buoys the downward component of anchor cable force becomes so large in currents of the order of 10 knots that the buoy completely submerges. In practice, it becomes difficult to provide enough buoyancy to prevent this from happening since increasing the volume to improve buoyancy also increases drag, so one only gains slowly at the expense of considerable dollar cost. In the current design, the buoy is made in a shape which produces aerodynamic lift and the cable is attached at a point which allows the structure to assume a positive angle of attack relative to the current. This lift, of course, generates drag, but since a value of L/D considerably greater than 1.0 is readily obtainable, the buoyancy is significantly augmented by lift in strong currents. This feature has been partially tested by the observation that, under tow at approximately 4 knots, the buoy assumed a very definite, stable positive angle of attack, thus qualitatively confirming that the cable attachment points were correctly chosen.

2. Electronics

In section 1-e-3 a technique is described for eliminating noise from the slow speed multiplex circuitry by locking out input for a pre-determined time. Although we rate this as an unremarkable approach to the problem, which may well have been used previously, we do not find mention of it in the literature.

3. Imagery Analysis

While the optical properties of water are well known, and the decreasing depth of penetration with increasing wave lengths of the four MSS channels is widely understood, we are not aware of previous applications of this as a sounding device. Accomodating for the fact that this sequential penetration phenomenon breaks down in very turbid waters, where the red band, number 5, may be expected to have maximum penetration, we are experiencing a degree of success in the mapping of subsurface turbidity layers by satellite imagery.

Program for Next Reporting Interval (21 Dec., 1972 - 21 Feb., 1973)

1. Buoy Platforms

All fiberglas boxes, including pressuring systems, are to be completed and lab-tested by Feb. 5th. Installation in the first buoy at sea is to be completed by Feb. 10th. On approximately Feb. 20th, there is to be a final inspection of the damage caused when the buoy washed ashore (see main text), and decision on whether reconstruction or replacement is necessary. Construction of the second buoy will not begin until after this inspection.

2. Buoy Instrumentation and Electronics, Including DCS

All electronic components and connectors are to be received by Jan. 23rd. All components relating to fiberglas box construction are to be delivered to the mechanical engineers by Jan. 28th. Lab-testing of complete systems installed in the fiberglas boxes is to take place during the period Feb. 5-9. Installation in the first buoy and beginning of data collection at sea is to take place by Feb. 10th. Inspection of the complete system at sea is to take place on approximately Feb. 20th. Planning and minor fabrication of systems for the second buoy will continue on as time permits during this reporting period, but major work on the electronics for the second buoy will not begin until after one month of satisfactory operation at sea by the first buoy.

3. Imagery Analysis

Photo-Interpretation work on ERTS-1 Imagery will proceed at accelerating rates during the next reporting interval, with the goal of analyses being completed on each increment one month after receipt of imagery and related ground observations in the photo-interpretation laboratory.

4. Data Library

Computer print-outs of raw data from each cruise will continue to be distributed to all participants designated as data recipients within one month of completion of the cruise. Algorithms for mapping horizontal distributions will be debugged by Jan. 25th, and pertinent horizontal distribution maps from each cruise will then be brought to schedule with the raw data. Algorithms for selected vertical profiles will be constructed by Feb. 15th, and will hopefully be de-bugged by Feb. 21st, with catch-up and distribution of these analyses as for the horizontal distributions.

In the absence of ERTS-1 RBV data, and of overflight scanner data, it is not possible to make definite predictions on when and how arrangements will be negotiated with the Purdue Laboratory for the Applications of Remote Sensing (LARS) for special digital analyses.

5. Project Coordination

On Feb. 2 and 3 we will hold our second coordination meeting of all participating scientists. This meeting will be held on the Tucson campus of the University of Arizona and will include special sessions on remote imagery analysis and computer programs.

Conclusions

Although a large number of specific ideas have come to mind in all portions of the investigation, and many working hypotheses have shown encouraging development under testing, it is deemed too early to formulate particular conclusions at this stage in the program.

Recommendations

1. It is recommended that our request for $1,675.00 additional funding for electronic equipment and materials to service DCP's be approved. This request was submitted in full detail in our Nov. 30th, Type I report, but no response has been received as yet. As explained in the original request, this additional funding is our proposed way of coping with problems for which NASA has apparently not been able to provide solutions through other avenues. It relates to non-continuance of NASA's original contract with the makers of the DCP's.

2. It is recommended that our present contract be extended through November, 1973. As was explained in detail in our Nov. 30, 1973 Type I report, late delivery of satellite imagery, insufficient get-ready time on the contract, and other factors beyond our control could result in the present investigation producing only 10 months of data, with the first portion of the data fragmentary and incomplete. This would cripple the primary objective of the contract, which is to quantify seasonality in the northern Gulf of California environment over a year period. A funding proposal for the recommended extension will be presented before the next Type I report is due, by which time it will be possible to provide better evidence of activity on which the proposed extension may be judged.

APPENDIX A

PROCEEDINGS OF NASA PARTICIPANTS MEETING, YUMA, ARIZONA, 2 DECEMBER, 1972

PROCEEDINGS OF NASA PARTICIPANTS MEETING, YUMA, ARIZONA, 2 DECEMBER, 1972

Attending: Dr. Saul Alvarez Borrego, U de Baja Calif. (Phys. & Chem. Oceanography)
Maestro Virgilio Arenas, UNAM (Productivity; Pesticides in plankton; Post-larval shrimp abundance)
Sr. David Cabrera, U of Ariz. (Captain of R/V "ADVENTYR")
Lt. Gustavo Calderon, Oceanography Section, Mexican Navy & U of A Grad Division (Photo-Interpretation)
Ms. Claudia Farfau, U de Baja Calif. (Plankton studies)
Sr. Luis Galindo, U de Baja Calif. (Phys. & Chem. Oceanography)
Dr. Richard Glenn, U de Baja Calif. (Marine ecology)
Sr. Sergio Guevara, U de Baja Calif. (Ichthyology)
Ms. Christine Flanagan, U of A (NASA program coordination; Ground truth data collection; Computer programming)
Dr. John Hendrickson, U of A(NASA Principal investigator)
Mr. Steven Howard, U of A (Buoy engineering)
Ing. Jose Ramon Infante Leon, U de Sonora (Ship management; General coordination)
Dr. Larry Lepley, U of A (Remote sensing; Imagery Analysis)
Mr. Robert Mangum, U of A (Electronics, ship and buoys)
Mr. Richard McCrory, U of A (Ground truth data collection; General support functions)
Ms. Janna McIntosh, U of A (Computer programming; Data handling)
Ocean. Katsuo Nishikawa, U de Baja Calif. (Coordination for U de Baja Calif.)
Ms. Amelia Nishikawa, U de Baja Calif. (Heavy metals in sediments & organisms)
Mr. G. Richard Stonesifer, NASA Washington (Technical monitor for program)
Ms. Patricia Stout, U of A (Secretary, General support functions)

Meeting 1 -- GROUND TRUTH OPERATIONS (1515 - 1830 hours)

A. Completion of Operational Handbook for the Project.

Copies of the latest draft of the handbook for data acquisition, storage, retrieval, and analysis were distributed and the purpose and structure of the handbook were explained briefly. It is hoped that this handbook will serve all participants as a standard reference, to produce uniformity of data and optimal coordination of efforts between the different participating institutions.

Following general explanation and discussion of the handbook, there was discussion of the Appendices which will describe the particular activities which each participating institution hopes to carry out. It was agreed that, in their initial form, each of the Appendices should represent the ideals which each institution had in mind, and that the following priority system and developmental process would take place:

1. First, the terms of the NASA contract must be fulfilled. All tasks listed in the contract will have priority over other activities which, if undertaken in addition to contract items,must have not-to-interfere status.

2. Second, each institution will prepare and circulate to the others its own Appendix to the handbook, listing the activities which it would ideally like to carry out, describing methods, instrumentation, data forms, etc. Appendix I, presently showing U of A NASA contract activities only, was presented as one form of the model which could be referred to in composing other appendices. Each of the above primary drafts of Appendices, including one from the U of A showing non-contract

activities in addition to contract tasks, should be circulated to the other participating institutions within the very near future.

3. Third, upon receipt of the other parties' suggestions (primary drafts of Appendices), there would be correspondence between institutions to reduce areas of duplication, accomplish plans for work-sharing, and accomodate for conflict with the first-priority contract tasks. The U of A is willing to serve as central clearing house for such work, but will leave resolution of two-party problems to the particular institutions immediately concerned (for example, possible duplication of pesticide studies by U de B.C. and UNAM).

4. After identification of overlaps and conflicts, any necessary compromises between the ideals of participants will have to be arranged; following this, the final forms of the Appendices describing each institution's planned activities will be written out and included in the handbook for long-term reference.

Appendix I, describing U of A contract activities, was presented in final form. To this will be added any additional, non-contract activities which the U of A will ideally like to undertake.

Appendix II, describing U de B.C. hydrographic studies desired, was presented in semi-final form (some of the data formats are in the process of being revised). In addition to this material which was passed out to each participating institution at the meeting, the following were noted as items on the U de B.C.'s list of activities which they would ideally like to carry out and for which descriptive Appendix material would soon be forthcoming:

1. Studies of nutrient distribution and assay of nutrients in the northern Gulf.
2. Heavy metals and chloro-hydrocarbon pesticides in sediments and animals.
3. Transect studies of intertidal biotas (some requiring ship time for access or extension of transects seaward).
4. Correlation of oceanographic data with fisheries product and effort (work on statistics, plus work on catch composition which might involve ship time).
5. Qualitative and quantitative plankton analysis and chlorophyll determinations.
6. Production of a bathymetric map of the northern Gulf.
7. Long-term studies of current patterns.
8. Special, intensive study of current patterns during period 11-29 March, in coordination with multi-ship survey of the entire Gulf of California.
9. Environmental analysis of presumed freshwater areas of the northern Gulf.

Appendix III, describing UNAM activities which they would ideally like to carry out was circulated. This draft version, made up by Maestro Virgilio Arenas on short notice at the meeting, describes activities, methods, and instrumentation; it needs only samples of data forms to be complete, although it is recognized that UNAM may wish to later amend this material which was composed under pressure of time.

No material was presented for Appendix IV, for the Universidad de Sonora. It was recognized that something might be presented by a deadline of December 10th, failing which UNISON would be recorded as participating through use of their ship "Adventyr" and their Puerto Penasco marine lab facilities, and that they would automatically receive copies of the computer data output for any analyses which they might like to carry out.

An important point established by unanimous agreement at the meeting was that all data acquired in the above studies will be freely and automatically transmitted to all institutions listed as data recipients in this study, subject only to certain formalities in the case of U de B.C. referring back to their separate granting agencies.

B. Cooperative Use of the R/V "ADVENTYR" and Instrument Buoys

The following working rules were agreed upon:

1. There will be a limit of 4 scientists per cruise, one designated "Chief Scientist".

2. Detailed description of individual plans for each cruise (names of persons, activities, instruments, etc.) will be mailed to Hendrickson at U of A, to arrive 14 days before embarcation date, with automatic copies to the other participating institutions (Nishikawa for U de B.C.; Arenas for UNAM; Infante for Unison). Receipt of cruise plan at U of A to be confirmed within two days of arrival by telegram or telephone call. Any required modifications of plans to be determined, and all parties notified (telegram or telephone call) by 7 days before embarcation date.

3. Within 14 days of cruise ending date, a report on each cruise will be prepared by the designated Chief Scientist for that cruise and sent out to each participating institution.

4. All of the originals of instrument charts are to be kept by U of A personnel and deposited permanently in the archives at the U of A. As necessary for the work of other institutions,these will be copied by either xerox or blueprinting process. If such copies prove inadequate and originals must be used by other institutions, they will be transferred out of the archives under high-security, loan conditions (hand-carrying or reply-certificate, registered mail within the U.S. mail system only).

5. Approximately every 30 days, newly acquired data will be run through the UA computer and copies mailed out to listed data recipients. On the same schedule, later generations of earlier data (with minor corrections or changes) will be transmitted.

6. The following regulations for shipboard living and work, suggested by the Captain at the request of the general meeting, were adopted in full:

   A. All meals eaten must be taken on time, and there will be set hours after which no food will be available (the galley must function as instrument room, etc.).

   B. Personal cleanliness, neatness in handling and disposal of personal gear, and consideration for the needs of others must reach a level far above what is normal while on land. All parties will feel perfectly free to call attention to problems in this area without fear of giving offense -- it is a ship's regulation and their duty to comply.

   C. Orderliness and efficiency in use and stowing of scientific gear is a "must."

   D. Each person should organize his work ahead of time.

   E. All scientists should help one another (this frequently means volunteering; sometimes the greatest help may be to keep out of the way).

   F. Conserve freshwater and electricity (shut off lights).

   G. Keep toilets clean.

H. All hands have responsibility to work at periodic clean-up of ship.

I. All hands must help as needed with ship operations such as pulling anchor, standing wheel watch, etc.

7. It was agreed that, hereafter, each participating institution will pay for food costs during cruises in proportion to the number of persons that institution has on board (i.e., on a cruise with two U of A scientists, one U de B.C. scientist, and one UNAM scientist, U of A will contribute 50% of the food costs, the other two institutions will each contribute 25%).

C. Ancillary Uses of Oceanographic Buoys

It was established that, at least for the present, none of the participants has need to place any equipment on the buoys other than the NASA instrumentation for which they were designed.

Meeting 2 -- DATA ANALYSIS PLAN (1930 - 2130 hours)

Ms. Flanagan and McIntosh explained the data analysis plans, following the description in the handbook. Copies of the computer data for cruises 1 and 2 were then passed out, and participants were guided through the forms with explanations as necessary. There was a period of questions and answers regarding opportunities for the other participating institutions to take advantage of U of A computer analysis facilities.

Meeting 3 -- OTHER PROJECT ACTIVITES (2130 - 2330 hours)

A. Lt. Calderon assisted by Dr. Lepley gave a presentation of photoanalysis work now in progress on ERTS-1 imagery, showing examples of analysis techniques which stimulated considerable discussion about new opportunities for obtaining desired information by way of the imagery.

B. Mr. Mangum gave an overview of the electronics involved in the program, particularly with respect to the instrument buoys relaying information by way of the satellite.

C. With Mr. Stonesifer's assistance, there was discussion of the ERTS-2 program and mechanisms for the Mexican participants to submit no-cost proposals through appropriate channels in Mexico. There was also discussion of continued cooperation in carrying out a program based on a U of A proposal for ERTS-2.

D. Ocean. Nishikawa announced that U de B.C. now has copies of the newly-acquired Gulf of California tidal data produced by Scripps Institution. He will send copies of this to Dr. Thomson at the U of A.

E. U de B.C. handed in data from cruise 3 (25-27 October) for archiving and processing.

F. U de B.C. called attention to the fact that there was going to be a special concentrated oceanographic investigation in the Gulf of California during the period 11-29 March, 1973. This program would stress studies of current patterns and would have the "AGASSIZ" and the "HUMBOLDT" working in more southerly sections of the Gulf; hopefully, the "ADVENTYR" might work at the same time in the northern portion of the Gulf as in coordination with the other two ships. It was agreed that this

would be desirable and that every effort should be made to coordinate our work with the major, general program during the period designated. This will be explored further to see how far our work and the "ADVENTYR'S" time may be integrated into the larger program.

G. U de B.C. announced that they plan to hold the First International Symposium on the Seas of Baja California in Ensenada in October of 1973. The hope was expressed that other institutions participating in the present program might have significant input to the symposium. Hendrickson, speaking for the U of A, expressed enthusiasm over the idea and pledged at least two (probably more) papers.

H. It was tentatively agreed that the next meeting of this group will be on January 26-27 in Tucson. The meeting would begin on the morning of Friday the 26th and last through Saturday the 27th. Hopefully, representatives from Scripps Institution and from Instituto de Pesca, Mexico City can attend to assist in planning the cooperative cruise mentioned in "F" above.

I. The U of A promised to produce and circulate a record of this meeting, which consists of the foregoing.

APPENDIX B

HANDBOOK OF DATA ACQUISITION, STORAGE, RETRIEVAL, AND ANALYSIS

3

NASA PROJECT

Study of Marine Environment of the Northern Gulf of California

HANDBOOK OF DATA ACQUISITION, STORAGE, RETRIEVAL, AND ANALYSIS

NOTE: IN USE OF THIS HANDBOOK AS AN APPENDIX IN REPORT TO NASA, SUPPLEMENTS 1 AND 2 ARE DELETED IN THE INTEREST OF SPACE CONSERVATION. NODC CODING KEYS AND DATA SUBMISSION ARE AVAILABLE FROM NODC, WASHINGTON, D.C.

NASA Project

Study of the Marine Environment of the Northern Gulf of California

Handbook of Data Acquisition, Storage, Retrieval, and Analysis

Data in support of the investigation will be acquired from the following three sources:

1. Oceanographic cruise data:
   a. University of Arizona - monthly hydrographic cruises for collection of physical and biological data from 47 assigned stations in the northern Gulf of California. See Appendix I.
   b. Universidad Autonoma de Baja California - hydrographic cruises for collection of physical and biological data from assigned stations in the northern Gulf of California. See Appendix II.
   c. Universidad Nacional Autonoma de Mexico - biological oceanographic data from the northern Gulf of California. See Appendix III.
   d. Universidad de Sonora - data contribution unspecified at this time (to be included as Appendix IV).
2. Remote oceanographic data collection buoy:
   a. University of Arizona - daily physical oceanographic data from two buoys in the northern Gulf of California with remote sensors and telemetry package.

b. Universidad Autonoma de Baja California - data contribution unspecified as of this time.

3. Earth Resources Technology Satellite-1 (ERTS-1) imagery in print, transparency and digital form.

Data from all three major sources is being cataloged and stored for analysis at the University of Arizona by means of an integrated data storage and retrieval computerized library system. The library system has three main divisions:

1. Ground observation data consisting of oceanographic observations made during cruises;
2. Ground observations made by remote oceanographic data collection platforms;
3. Remote sensing imagery from satellite sources.

The plan proposed below concerns only the first two divisions of the data library since raw data input to division three is the contracted responsibility of the National Aeronautics and Space Administration (NASA).

Data Storage, Retrieval and Dissemination System

Ground data is received from two major sources, representing four institutions as stated above. The objectives of the data storage, retrieval and dissemination system are as follows:

1. Inventory all data collected in the investigation by contractee and cooperating institutions.
2. Storage of all data in standardized manner that is acceptable to all cooperating scientists and which facilitates data retrieval

and analysis by computer or other means.

3. Disseminate all data collected to cooperating scientists in standardized form.

4. Storage in form acceptable to National Oceanographic Data Center; dissemination of Gulf of California data for archiving into international oceanographic data bank (NODC).

Figure 1 illustrates the route of data flow in and out of data library system.

Data are submitted by cooperating institutions in suitable form for processing into the library. The data submission format will depend upon the type of study undertaken by the institution (biological data, physical oceanographic data, etc.) but should in any case meet the following minimum requirements:

1. Accompanying each data set should be an explanatory form which identifies the purpose of the data collection, the parameters measured, instruments used, chief personnel, dates, etc.

2. Location by latitude and longitude of each data point should be identified. If possible, a station map or map of collecting sites should be furnished.

3. The data for each locality should be submitted on a suitable standardized form which includes appropriate climatological information, environmental parameters and preserving techniques (specimens or samples collected).

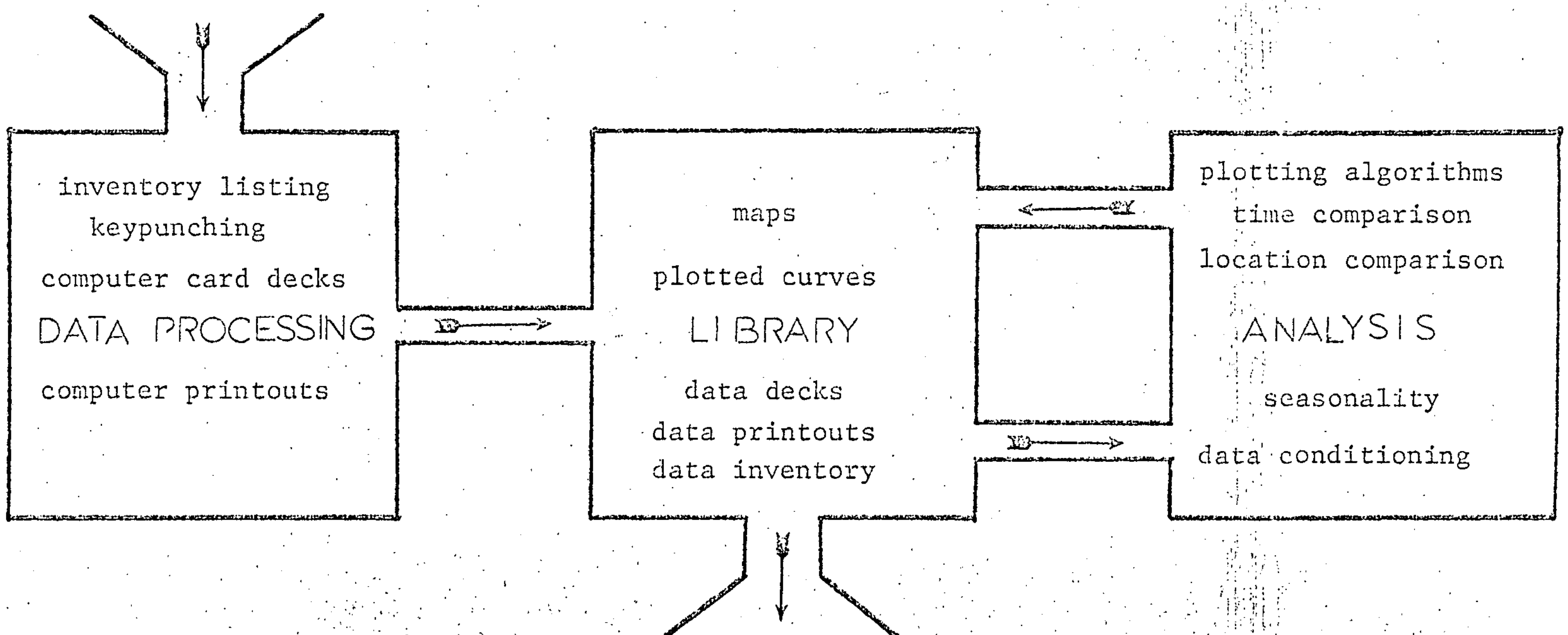
Whenever possible, copies of the actual data recording forms should be the data submission form.

FIGURE 1: Data flow within proposed data library and analysis system

DATA

Submitted by

cooperating institutions



DISSEMINATION

to cooperating scientists

Data received from cooperating institutions are keypunched and stored in card form and a computer printout is generated. Once each month, computer printouts of all data entered into the library during the preceding 30 days will be disseminated to user institutions. Upon user request, card decks can also be supplied for any specific data site.

The keypunch computer storage format of the library system follows the guidelines set down in National Oceanographic Data Center (NODC), "Manual for Coding and Keypunching Biological Data" and NODC "Processing Physical and Chemical Data from Oceanographic Stations, Part 1, Coding and Keypunching." While most data that will appear on any data computer printout will be in readable form, climatological data will be in coded form; a copy of coding keys follows as Supplement 1 to this report.

A computer listing will also be available of the data set inventory which provides acquisition information for each data set in storage; each entry consists of: 1) member institution supplying data; 2) date of data collection; and 3) data character.

All data collected as a result of this project will be supplied to the National Oceanographic Data Center. Models of the NODC form are included in the handbook as Supplement 2.

This handbook is intended to supply information to cooperating institutions and to solicit responses and suggestions for improvement. Appendix I contains models of data forms in use by the University of Arizona; these forms serve to illustrate the minimum data submission requirements outlined above. A short summary of the type of data that the University of Arizona will submit to the library is also included.

Appendix II contains the data collection plans and model forms to be used by the Universidad Autonoma de Baja California. Appendices III and IV reflect the plans of the Universidad Nacional Autonoma de Mexico and the Universidad de Sonora respectively.

APPENDIX I

University of Arizona

Ground Data Collection

NASA Project, Study of the Marine Environment of the Northern Gulf of California

Ground Data Collection

1. Monthly hydrographic cruises to collect data from 47 stations are planned. Figure 1 is a map of planned stations in the northern Gulf of California and Table 1 lists each station by latitude, longitude and assigned station location. Table 2 lists the parameters to be measured and samples to be collected from each station, with associated instruments or equipment. Navigation and repetitive station location is to be accomplished by means of an Omega Model 110 Navigational Receiver. The station data recording form is included as Figure 2. Figures 3, 4, and 5 illustrate models of the data set summary forms which summarize the work performed during the collection of one data set (oceanographic cruise).
2. Daily oceanographic data will be collected from two remote data collection buoys. Each buoy contains instruments for desired parameters, signal conditioning electronics, and telemetry package for transmitting data to the ERTS-1 satellite. Table 3 lists the parameters to be measured on the remote data collection buoys and associated instrumentation.

Data from the buoys will be transmitted to the satellite, where it is beamed back to an earth-based receiving center for processing. It is then forwarded to the University of Arizona in punched-card and print-out form.

Table 4 lists other types of activities in which University of Arizona personnel may engage on a not-to-interfere/target-of-opportunity basis.

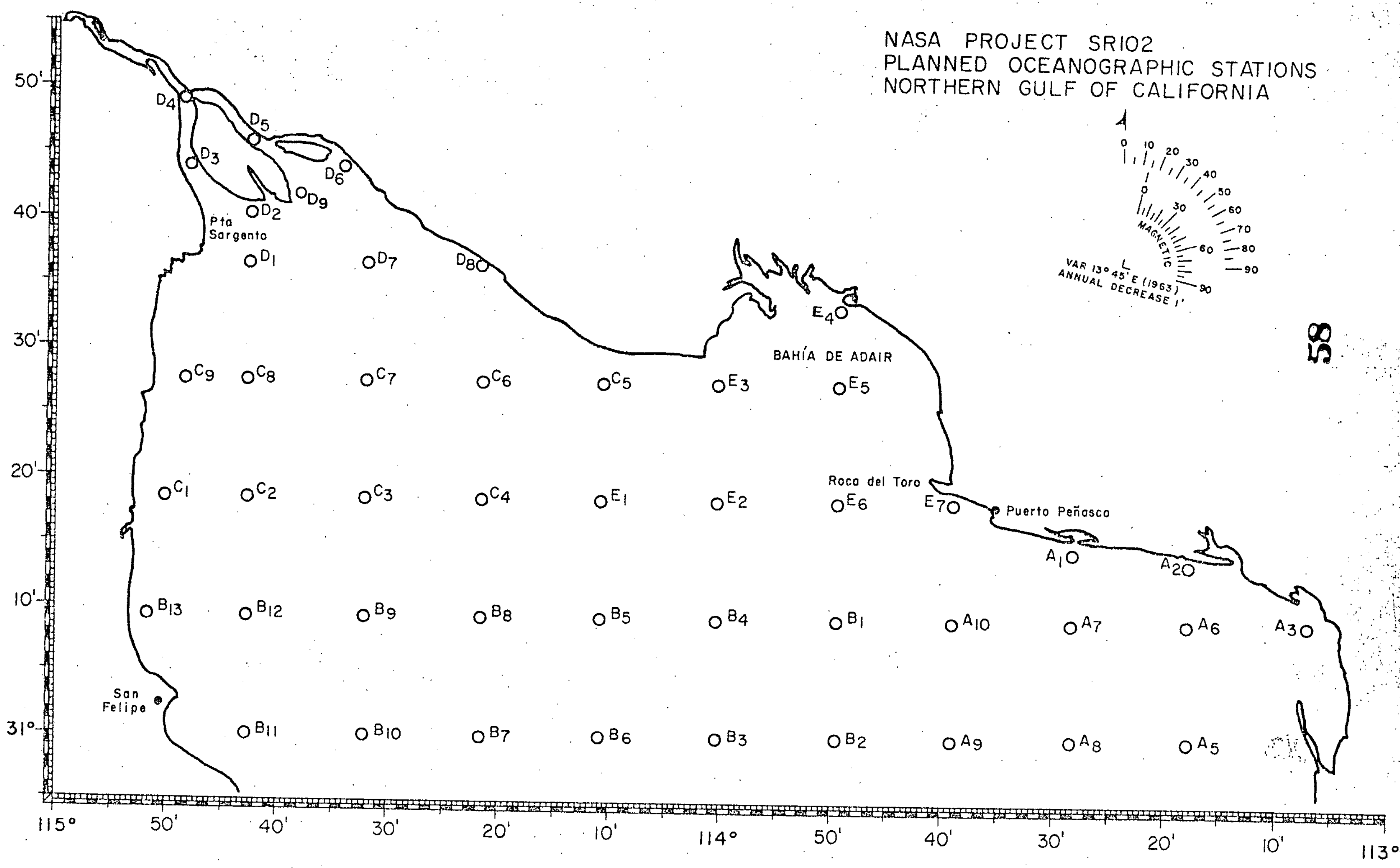

NASA PROJECT SR102
PLANNED OCEANOGRAPHIC STATIONS
NORTHERN GULF OF CALIFORNIA
MAGNETIC
VAR 13° 45' E (1963)
ANNUAL DECREASE 1'
Pta Sargento
BAHÍA DE ADAIR
Roca del Toro
Puerto Peñasco
San Felipe
D4
D5
D3
D6
D9
D2
D1
D7
D8
E4
C9
C8
C7
C6
C5
E3
E5
C1
C2
C3
C4
E1
E2
E6
E7
A1
A2
B13
B12
B9
B8
B5
B4
B1
A10
A7
A6
A3
B11
B10
B7
B6
B3
B2
A9
A8
A5
50'
40'
30'
20'
10'
31°
115°
114°
113°

Figure 1

Project No.	Station No.	lat.	sonar depth	wind	temp.	clouds	sea	swell	con. no.	weather
Vessel		long.		speed	dry	type	ht.	ht.		
Date	Time	navig.	Barometer	dir.	wet	amt.	dir.	dir.	visibility	

SALINITY-TEMPERATURE-CONDUCTIV. Instrument		Parameters	D1	D2	D3	D4	D5	D6
time in	wire angle	conductiv.						
		temperat.						
time up	wire angle	salinity						

CURRENT Instrument

Depth	X vector	Y vector	heading	speed	angle	direct
D1						
D2						
D3						

PLANKTON SAMPLING	sample 1	sample 2	sample3	sample 4	sample 5
wire length					
wire angle					
type					

TURBIDITY
Instrument

wire length	Deck cell	X factor	sea cell
D1			
D2			
D3			
D4			
D5			
D6			

Secchi Disk reading

OMEGA Computations

LOP1 B-D reading	
St.1 PPC	
St.2 PPC (-)	
Tot. Correct.	
Corrected reading	
LOP2 C-D reading	
St.1 PPC	
St.2 PPC (-)	
Tot. Correct.	
Corrected reading	
Longitude	Latitude

OTHER SAMPLES (Specify)

COMMENTS

BOTTLE CASTS

no.	time	depth	angle	temp.	samp #	DO	PL	specify	specify	specify	specify

Time abandon station

Heading to next station

Figure 2 (Station Data Recording Form)

FILED BY ____________________ PROJECT SUMMARY SHEET DATE ____________________

PROJECT NO.	PROJECT TITLE
VESSEL	INCLUSIVE DATES
NO. OF STATIONS PLANNED	NO. OF STATIONS TAKEN
LIST OF STATIONS OMITTED	
STATION MAP ATTACHED	STATION LIST ATTACHED
CHIEF SCIENTIST	CAPTAIN

DESCRIPTION OF PURPOSE & AREA SAMPLED

OTHER SCIENTIFIC PERSONNEL	GENERAL REMARKS

PARAMETER	EQUIPMENT OR INSTRUMENTS	REMARKS

Figure 3

TYPE OF SAMPLE OR RECORD	STORAGE LOCATION	DISSEMINATED TO	COPY	ORIGINAL	DATE

TYPES OF ANALYSES, COMPUTATIONS, CALIBRATIONS	ANALYST	FILE LOCATION	DISSEMINATED TO	DATE

Figure 4

BIOLOGICAL SAMPLES

TYPE	ORIGINAL PRESERVATIVE	OTHER PROCESSING

Figure 5

Table 1

Oceanographic Stations, NASA Project, Northern Gulf of California

STATION NO.	LATITUDE (to nearest 0.5')	LONGITUDE (to nearest 0.5')
A1	31° 14.0' N.	113° 28.0' W.
A2	31° 13.5'	113° 17.5'
A3	31° 09.5'	113° 07.0'
~~A4~~	~~31° 00.0'~~	~~113° 07.0'~~
A5	31° 00.0'	113° 17.5'
A6	31° 09.5'	113° 17.5'
A7	31° 09.5'	113° 28.0'
A8	31° 00.0'	113° 28.0'
A9	31° 00.0'	113° 38.5'
A10	31° 09.5'	113° 38.5'
B1	31° 09.5'	113° 49.0'
B2	31° 00.0'	113° 49.0'
B3	31° 00.0'	114° 00.0'
B4	31° 09.5'	114° 00.0'
B5	31° 09.5'	114° 10.5'
B6	31° 00.0'	114° 10.5'
B7	31° 00.0'	114° 21.5'
B8	31° 09.5'	114° 21.5'
B9	31° 09.5'	114° 31.5'
B10	31° 00.0'	114° 31.5'
B11	31° 00.0'	114° 42.5'
B12	31° 09.5'	114° 42.5'
B13	31° 09.5'	114° 51.5'
C1	31° 18.5'	114° 50.0'
C2	31° 18.5'	114° 42.5'
C3	31° 18.5'	114° 31.5'
C4	31° 18.5'	114° 21.5'
C5	31° 27.5'	114° 10.5'
C6	31° 27.5'	114° 21.5'
C7	31° 27.5'	114° 31.5'
C8	31° 27.5'	114° 42.5'
C9	31° 27.5'	114° 48.0'
D1	31° 36.5'	114° 42.5'
D2	31° 40.0'	114° 42.5'
D3	31° 44.0'	114° 48.0'
D4	31° 49.0'	114° 48.5'
D5	31° 46.0'	114° 42.5'
D6	31° 44.0'	114° 34.0'
D7	31° 36.5'	114° 31.5'
D8	31° 36.5'	114° 21.5'
D9	31°42.0'N.	114°37.5'W.
E1	31° 18.5'	114° 10.5'
E2	31° 18.5'	114° 00.0'
E3	31° 27.5'	114° 00.0'
E4	31° 33.0'	113° 49.0'
E5	31° 27.5'	113° 49.0'
E6	31° 18.5'	113° 49.0'
E7	31° 18.5'	113° 38.5'

Table 3

Parameters to be measured on remote data collection buoys
with associated instrumentation

PARAMETER	MANUFACTURER & MODEL
Conductivity with temperature	Inter Ocean Model 513
Current velocity and direction	Marsh-McBirney Model 711
Wind velocity and direction	Bendix Model 120
Temperature (air and water)	Yellow Springs Instrument Models 701, 705
North-seeking device	Humphrey Model NS 04-0301-1
Dissolved oxygen	Weston & Stack Model 3000-1-A with A40 probe, A25 agitator
Turbidity	Monitor Technology Model W-350

Table 4

Possible ancillary activities by the University of Arizona

Deep water trapping, netting, long-lining (Wagner Basin)
Trawl sampling on station grid
Bottom grab sampling of benthic in-fauna
Sediment coring
Beach seining
Larval fish collecting (seine and trawl)
Night light collections
Sea bird and cetacean log

APPENDIX II

INSTITUTE OF OCEANOLOGICAL RESEARCH, UNIVERSIDAD AUTONOMA DE BAJA CALIFORNIA

Ground Data Collection

The hydrographic study of the northern Gulf of California which is here briefly described was designed originally according to a plan for environmental research subsidized principally by the Secretariat of Hydraulic Resources of Mexico and in a small part by the Ocean Research Foundation. This plan is intended to have sufficient flexibility to allow the successful pursuit of the research objectives which were undertaken in collaboration with the University of Arizona without conflict with the original objectives.

Cruises are made monthly. Eighteen stations, distributed over a section of the northern Gulf (see Table 1 and refer to Figure 1 of U. of A. Appendix I) are to be visited during each cruise. The latitude and longitude of each of the eighteen stations is noted in Table 1.

Table 2 lists the parameters measured and specifies the type and model of instrument used or the method employed. Navigation on board the ship "Adventyr" has been by dead reckoning, but is now by an Omega Navigational Receiver Model 1100; this apparatus permits more precise localization of stations.

The data sheets for physical, chemical and meteorological measurements are represented as Figures 1 through 8. The water samples for nutrient analysis are preserved by the addition of a drop of saturated solution of mercuric chloride and immediately afterward placing the sample in a dry ice freezer box.

The data sheets for biological collections are the same as those used by the University of Arizona.

INSTITUTE OF OCEANOLOGICAL RESEARCH

TABLE 1.

Locations of hydrographic stations for the program of the secretariat of Hydraulic Resources in the northern Gulf of California.

STATION	LATITUDE (N)	LONGITUDE (W)
1 = U.of A. D9	31°42.0'	114°37.5'
2 = U.of A. D5	31°45.0'	114°41.5'
3 = U.of A. D4	31°49.0'	114°49.0'
4 = U.of A. D3	31°48.0'	114°48.5'
5 = U.of A. D2	31°39.0'	114°43.0'
6 = U.of A. D1	31°36.5'	114°45.5'
7 = U.of A. C9	31°25.0'	114°49.5'
8 = U.of A. C8	31°31.0'	114°43.0'
9 = U.of A. D7	31°35.0'	114°36.5'
10 = U.of A. D8	31°39.0'	114°29.5'
11 = U.of A. C6	31°32.0'	114°24.5'
12 = U.of A. C7	31°26.5'	114°33.5'
13 = U.of A. C2	31°21.0'	114°42.5'
14 = U.of A. C1	31°16.0'	114°51.0'
15 = U.of A. B13	31°08.0'	114°51.0'
16 = U.of A. B12	31°15.0'	114°40.0'
17 = U.of A. C3	31°22.0'	114°28.0'
18 = U.of A. C5	31°28.5'	114°17.5'

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TABLE 2

PARAMETERS	INSTRUMENT OR METHOD
Salinity	Hytech (Bisset-Berman)
Temperature	Bucket Thermometer Reversible Thermometer
Oxygen	Winkler Method
PH	Orion PH meter, Battery, Model 407
Alkalinity	Orion (digital) Model 801
Silicates	Spectrophotometer-Coleman Hitachi Model 139
Phosphates	Spectrophotometer-Coleman Hitachi Model 139
Nitrates	"
Nitrates	"
Temperature & Humidity	Psychrometer
Pressure	Barometer ("Adventyr")
Velocity & Direction	Anemometer (Kahlsico) Model 03AM120
Turbidity	Secchi Disc.

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I.I.O.

Control General de Datos

HOJA DE

BARCO:

CLAVE DE CRUCERO	FECHA DEL CRUCERO

Nº EST.	LOCALIZACION		HORA		prof. de fondo	nivel de muest.	T°C	S‰	O_2 ml/l	PH	SiO_2 µM	NO_3 µM	NO_2 µM	PO_4 µM	LECTURA DISCO DE SECCHI
	LATITUD	LONGITUD	llegada	salida											

U. A. [illegible] C.
INSTITUTO DE INVESTIGACIONES OCEANOLOGICAS
DEPTO. DE OCEANOGRAFIA FISICA

OBSERVACIONES EN LA COSTA
HOJA NUM.____

LOCALIDAD	DIA/MES/AÑO	HORA	T°C AMBIENTE		VIENTO		NUBOSIDAD		T°C SUP.	OLEAJE			MUESTRA NUM.			T H C		TIPO DE COSTA
			B. SECO	B. HUMEDO	VEL.	DIR.	TIPO	%		DIR.	H	T	S ‰	O_2		T°	S‰	

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I.I.O.

HOJA DE

BARCO:

CLAVE DEL CRUCERO:

FECHA DEL CRUCERO:

ANALISTA:

FECHA DE ANALISIS:

CONTROL BOTELLAS DE S‰

EST.	HORA		PROF. DEL FONDO	NIVELES	No. DE BOTELLA	S‰	T°C	TRANS.	OBSERVACIONES:
	LLEGAR	SALIR							

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DETERMINACION I.I.O DE SALINIDAD POR SALINOMETRO

HOJA	DE
Barco	
Clave del crucero	Clave de estaci
Analista:	
Fecha de analisis	/ /

Temperatura de la muestra °C	Numero de compensacion
Numero de standard	

Numero del Salinometro

PROFUNDIDAD L	NUMERO DE BOTELLA	CONDUCTIVIDAD 1ª DETERMINACION	2ª DETERMINACION	PROMEDIO	SALINIDAD SIN CORRECCION	CORRECCIONES ‰ DESVIACION	TEMPERATURA	TOTAL	SALINIDAD	NOTACIONES
	STD.									

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OXIGENO I.I.O.

Hoja	de
Barco:	
Clave de crucero	Clave de estacion
Analista:	
Fecha de analisis: / /	

Determinacion de Oxigeno Disuelto por el metodo de Winkler.

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Determinacion del factor de Conversion

BLANCO:

V_B Primera determinacion =

V_B Segunda determinacion =

V_B Promedio total = ______

NORMALIZACION DE $Na_4 S_2 O_3$

V_S Primera determinacion =

V_S Segunda determinacion =

V_S Tercera determinacion = ______

Total

V_S *PROMEDIO* =

Volumen de la muestra titulada ☐ 50 ml. ☐ 100 ml.

PARA UNA MUESTRA TITULADA DE 50 ml. Y UN FRASCO DE 120 ml. VOLUMEN

$$K = \frac{11.577}{V_S - V_B}$$ ______

PARA UNA MUESTRA TITULADA DE 100 ml.

$$K = \frac{5.789}{V_S \quad V_B} = $$ ______

OXIGENO DISUELTO ml/L

K Determinada arriba

V Volumen corregido

PROFUNDIDAD m	NUMERO DE BOTELLA	1º LECTURA EN LA BURETA Vml.	2º LECTURA EN LA BURETA Vml.	PROMEDIO 1- Y 2- Vml	VOLUMEN DE BLANCO V_B	VOLUMEN CORREGIDO V	OXIGENO DISUELTO ml/L	NOTACIONES

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DE BAJA CALIFORNIA 8

I.I.O

DETERMINACION DE pH

HOJA	DE
BARCO	
Clave Crucero:	CLAVE EST.
Analista	Fecha de Analisis

Z	No. de BOTELLA	T° in situ	T° muestra	pH in situ	pH corregido	OBSERV.

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I. I. O.

DETERMINACION DE ALCALINIDAD

HOJA	DE
BARCO	
Clave de crucero	Clave de Estacion
ANALISTA	Fecha

Z	No. de BOTELLA	T° in situ	S‰	pH observado	aH	F	Alcalinidad total en meq/L	OBSERV.

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DE BAJA CALIFORNIA

I.I.O.

Hoja de

Barco:

CLAVE DE CRUCERO

FECHA DE CRUCERO

Control de botellas "NUTRIENTES"

No. ESTA.	PROF. DE FONDO	NIVEL DE MUEST	No. DE BOTELLA	TEMPERATURA (°C)	SALINIDAD S‰	OBSERVACIONES

APPENDIX III

INSTITUTO DE BIOLOGIA
UNIVERSIDAD NACIONAL AUTONOMA DE MEXICO

Ground Data Collection

This study is to be carried out in cooperation with the University of Arizona NASA project, Study of the Marine Environment of the Northern Gulf of California.

1. Quarterly estimation of the primary production at the 47 standard stations is planned. See figure 1 and table 1 of Appendix I for station locations.

   *a) A sample of 3 liters of surface water will be taken at each station. The sample will be filtered through filter paper of pore size .3 GFC for determination of chlorophyll content using the Richards and Thompson process.

   *b) A sample of 100 ml. of surface water will be taken at each station for preservation with lugol-acetate for identification and quantification of number and biomass of phytoplanktonic organisms under a plankton microscope.

   c) Estimation of rate of C^{14} fixation by the cell biomass at 6 - 9 selected stations (provisionally: D7, E5, A3, C4, B4, B2, A5, B11 and C2). The method used will be that of Steeman Nielsen, but using liquid scintillation counter. The incubation will be on the Hawaiian pattern incubator.

   d) Estimation of the excretion of organic material of phytoplanktonic cells produced by recent photosynthesis at the same 6 - 9 selected stations as for paragraph c. The method will be the counting of C^{14} radoatopm on filtered water obtained as per paragraph c, using liquid scintillation counter.

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* It would be useful for us to be provided with these samples on a monthly basis.

e) Estimation of the nutrient concentrations as 6 - 9 selected stations (as para c). Samples will consist of 130 ml. of water taken from the surface and from the bottom in polyethylene bottles. Samples will be analyzed in Mexico City for PO_4, NO_3, NO_2, NH_3 and possibly SiO_2. All samples except those for NO_3 determination will be preserved in 1% chloroform.

f) Estimation of pH will be made at all 47 locations using a Beckman G pH meter.

g) At especially selected stations (chosen after preliminary cruise), daily variation samplings will be made. The following schedule will be employed:

Phytoplankton samples ....Every 3 hours

Pigment samples ....Every hour

C^{14} fixation..........................4 times during the day

Nutrient samples......................3 times during the day

pH ....every hour

Oxygen samples ....every 2 hours

2. Estimation of pesticides bioaccumulated by plankton.

a) Plankton from all 47 stations, collected with zooplankton net and dried, will be used for estimation of pesticides. This cannot be accomplished until the necessary equipment is acquired. The plankton will be dried in a silica gel dessicator and mailed to Mexico City where the samples will be stored awaiting equipment (Packard gas chromatograph).

b) Daily variations of pesticides content of plankton will be studied at the especially selected stations mentioned in item g. Superficial trawls with a 1/2 meter net of #6 mesh will be made every 3 hours.

*3. If possible, monthly sampling of postlarval shrimp abundance.

a) Samples of the superficial waters from each of the 47 stations, using a 1/2 meter plankton net with #6 mesh; samples preserved in 6% formalin neutralized with marble chips. After sorting out shrimp postlarvae, send these plus aliquot of remnant to CPOM (Sorting Center of Mexico) at Mexico City. The postlarvae will be used for estimation of dried biomass and volume.

b) During autumn, special samples must be taken in order to detect with better accuracy the date of maximum abundance.

(No sample forms provided as yet)

* It would be useful for us to be provided with these monthly samples.

APPENDIX IV

Universidad de Sonora

Ground Data Collection

in cooperation with the University of Arizona NASA project, Study of Marine Environment of the Northern Gulf of California.